US012135631B2

(12) **United States Patent**
**Jothiprakash et al.**

(10) **Patent No.: US 12,135,631 B2**
(45) **Date of Patent: Nov. 5, 2024**

(54) **ASSISTED DETECTION OF APPLICATION PERFORMANCE ISSUES USING SERVERLESS COMPUTE TEMPLATES**

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( * ) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 439 days.

(21) Appl. No.: **17/037,062**

(22) Filed: **Sep. 29, 2020**

(65) **Prior Publication Data**

US 2022/0100636 A1 Mar. 31, 2022

(51) **Int. Cl.**
***G06F 9/44*** (2018.01)
***G06F 9/54*** (2006.01)
***G06F 11/36*** (2006.01)

(52) **U.S. Cl.**
CPC ..... ***G06F 11/3612*** (2013.01); ***G06F 9/547*** (2013.01)

(58) **Field of Classification Search**
None
See application file for complete search history.

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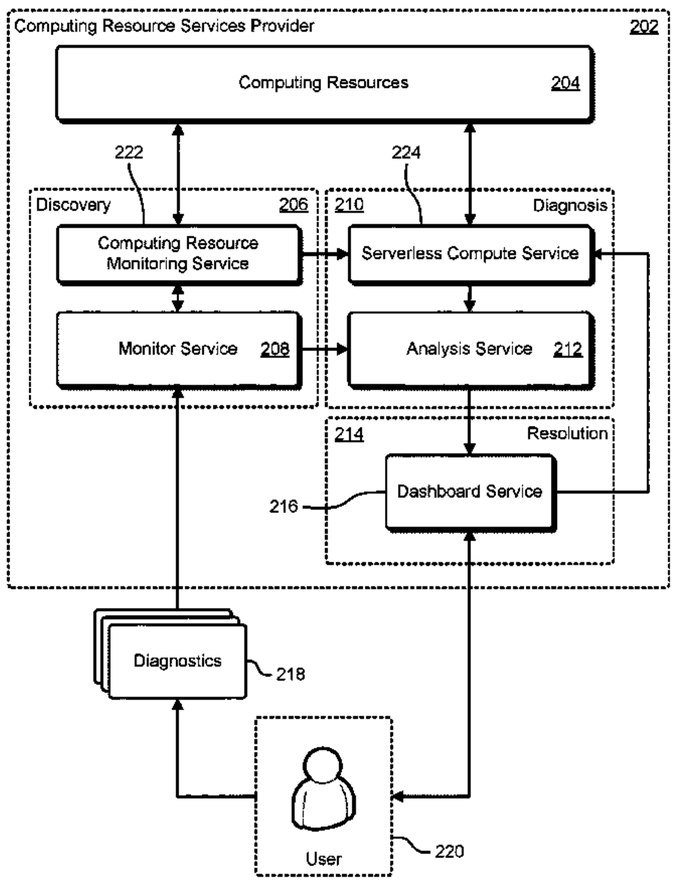
(57) **ABSTRACT**

A computing resource services provider receives user diagnostics comprising analysis operations to be performed on one or more computing resources. The computing resource services provider monitors resources indicated by the user diagnostics. When one or more computing resources exceed a threshold value or otherwise indicate abnormalities in computing resource usage, the computing resource services provider performs one or more analysis operations to determine one or more causes for increased computing resource usage. Results of the one or more analysis operations are presented to a user once the computing resource services provider completes the one or more analysis operations.

**19 Claims, 8 Drawing Sheets**



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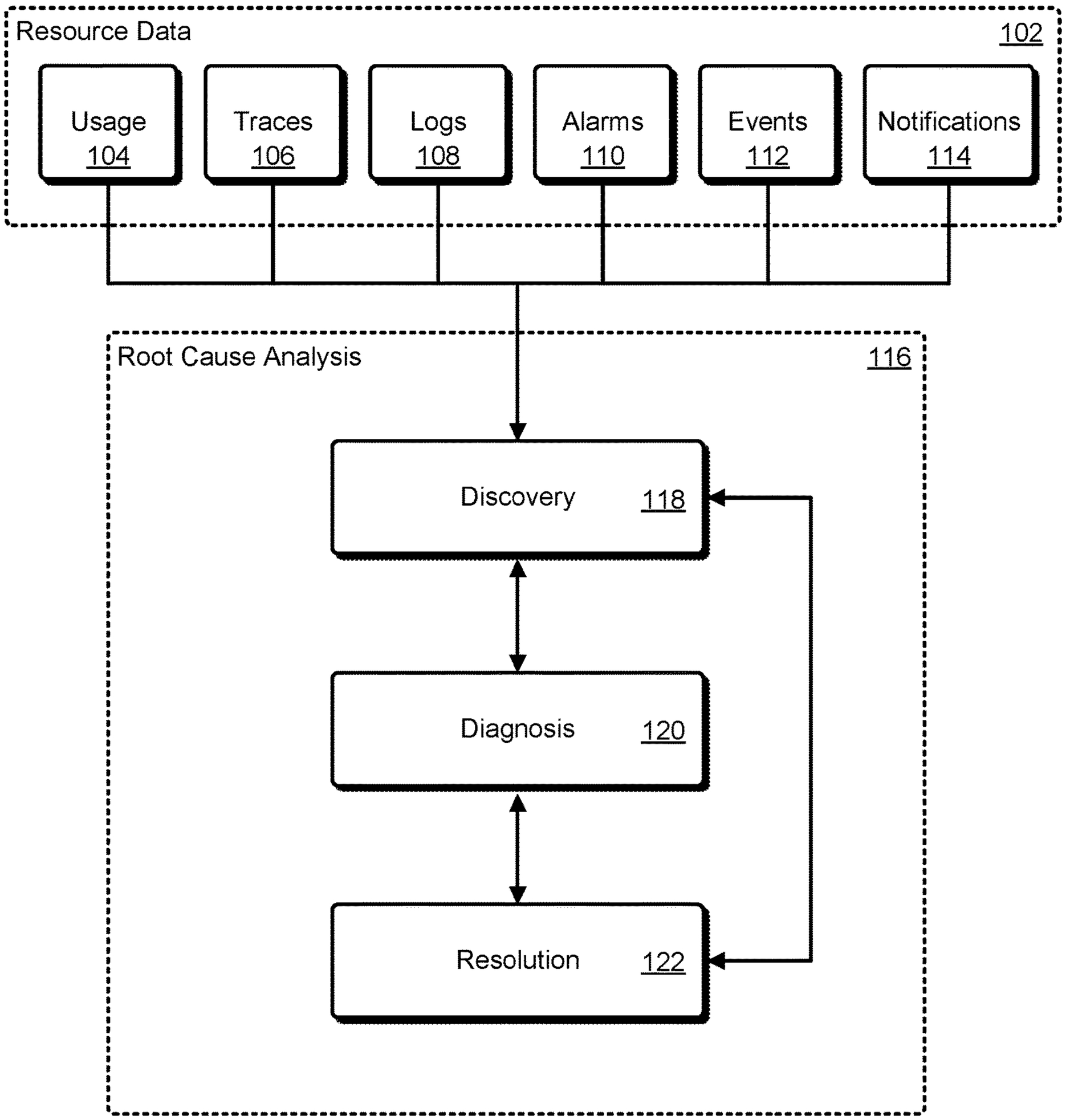
Resource Data
102
Usage
104
Traces
106
Logs
108
Alarms
110
Events
112
Notifications
114
Root Cause Analysis
116
Discovery
118
Diagnosis
120
Resolution
122

FIG. 1

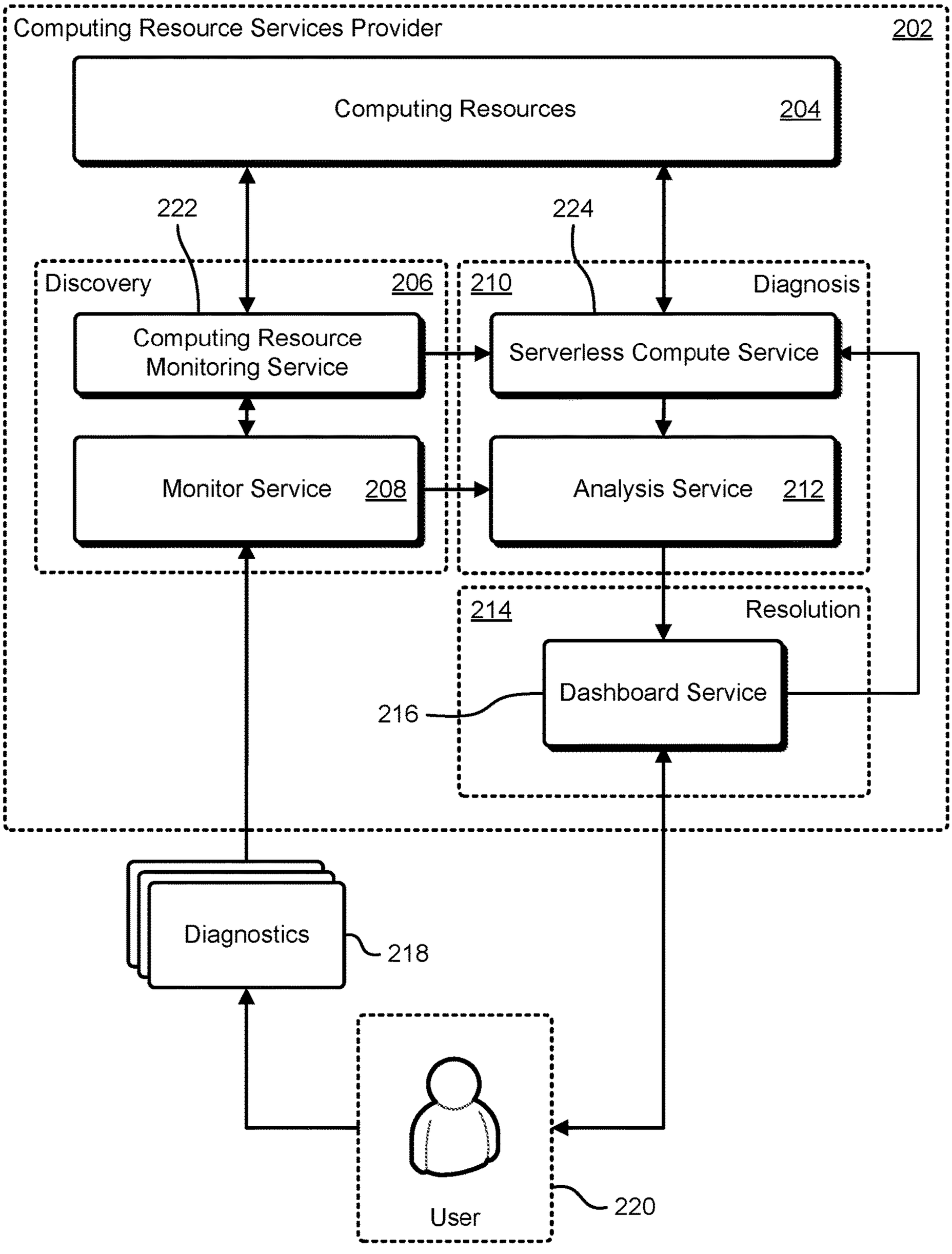
Computing Resource Services Provider
202
Computing Resources
204
222
224
Discovery
206
210
Diagnosis
Computing Resource Monitoring Service
Serverless Compute Service
Monitor Service
208
Analysis Service
212
214
Resolution
Dashboard Service
216
Diagnostics
218
User
220

FIG. 2

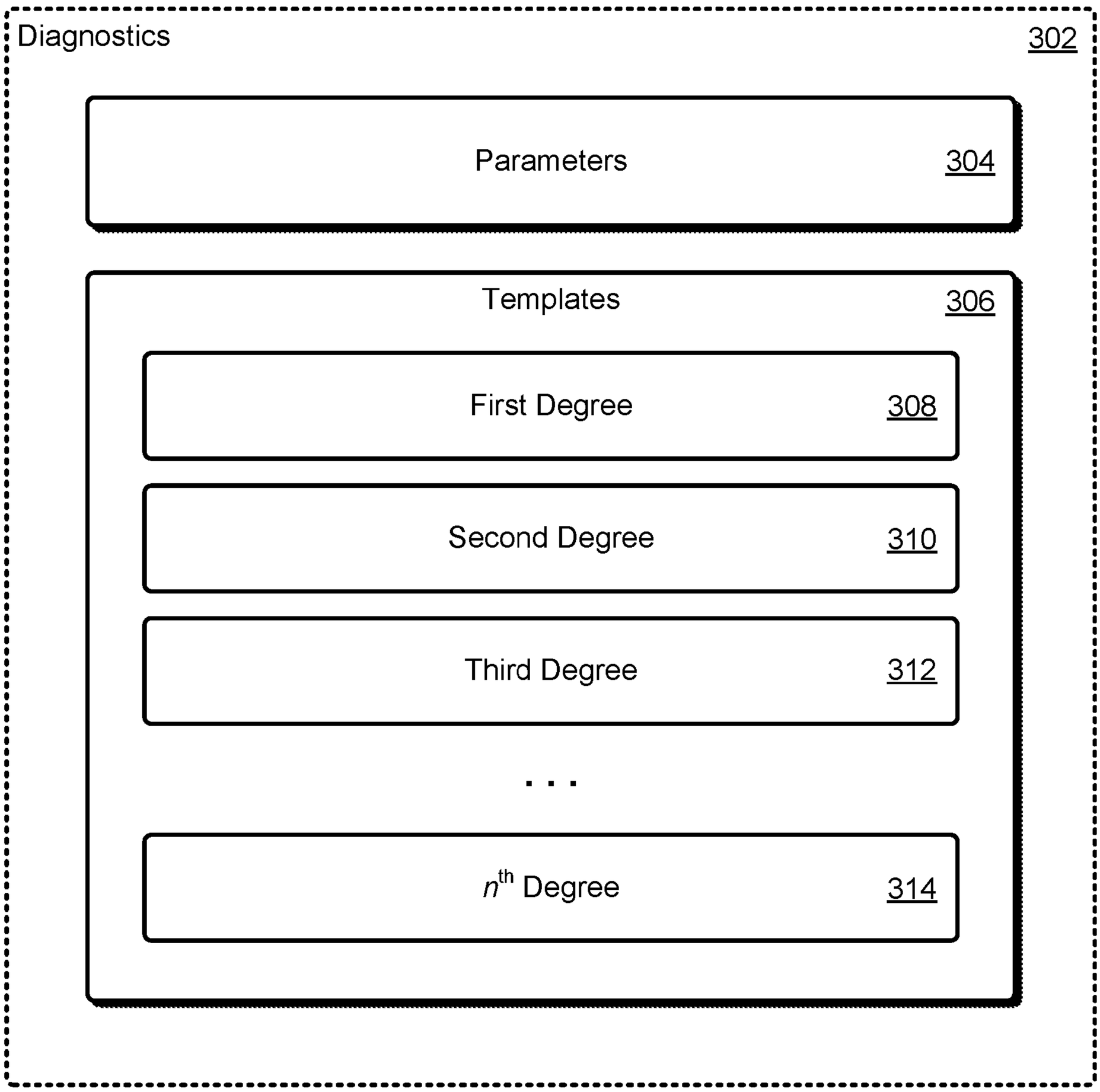
Diagnostics
302
Parameters
304
Templates
306
First Degree
308
Second Degree
310
Third Degree
312
. . .
$n^{th}$ Degree
314

FIG. 3

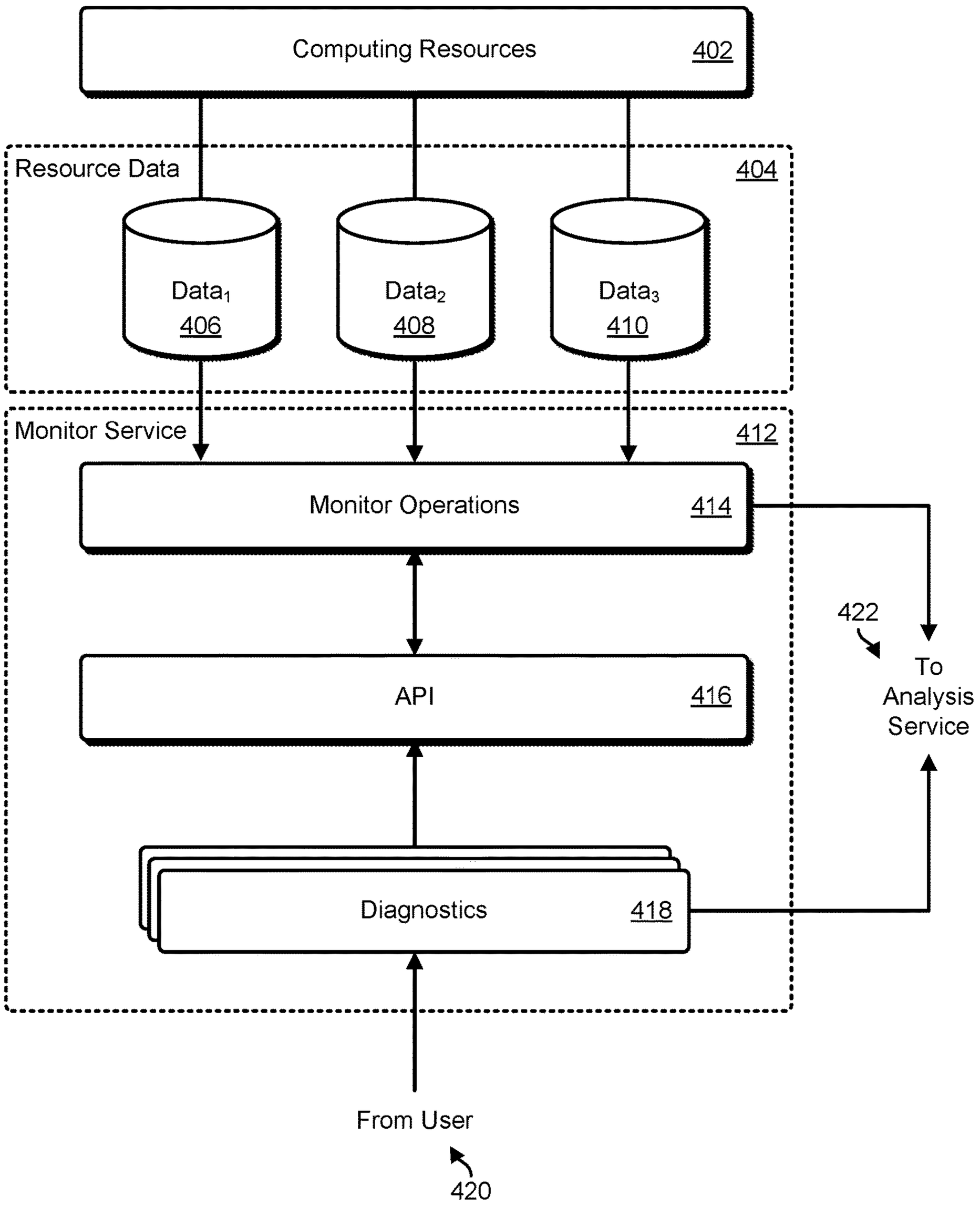
Computing Resources
402
Resource Data
404
Data1
406
Data2
408
Data3
410
Monitor Service
412
Monitor Operations
414
API
416
Diagnostics
418
422
To
Analysis
Service
From User
420

FIG. 4

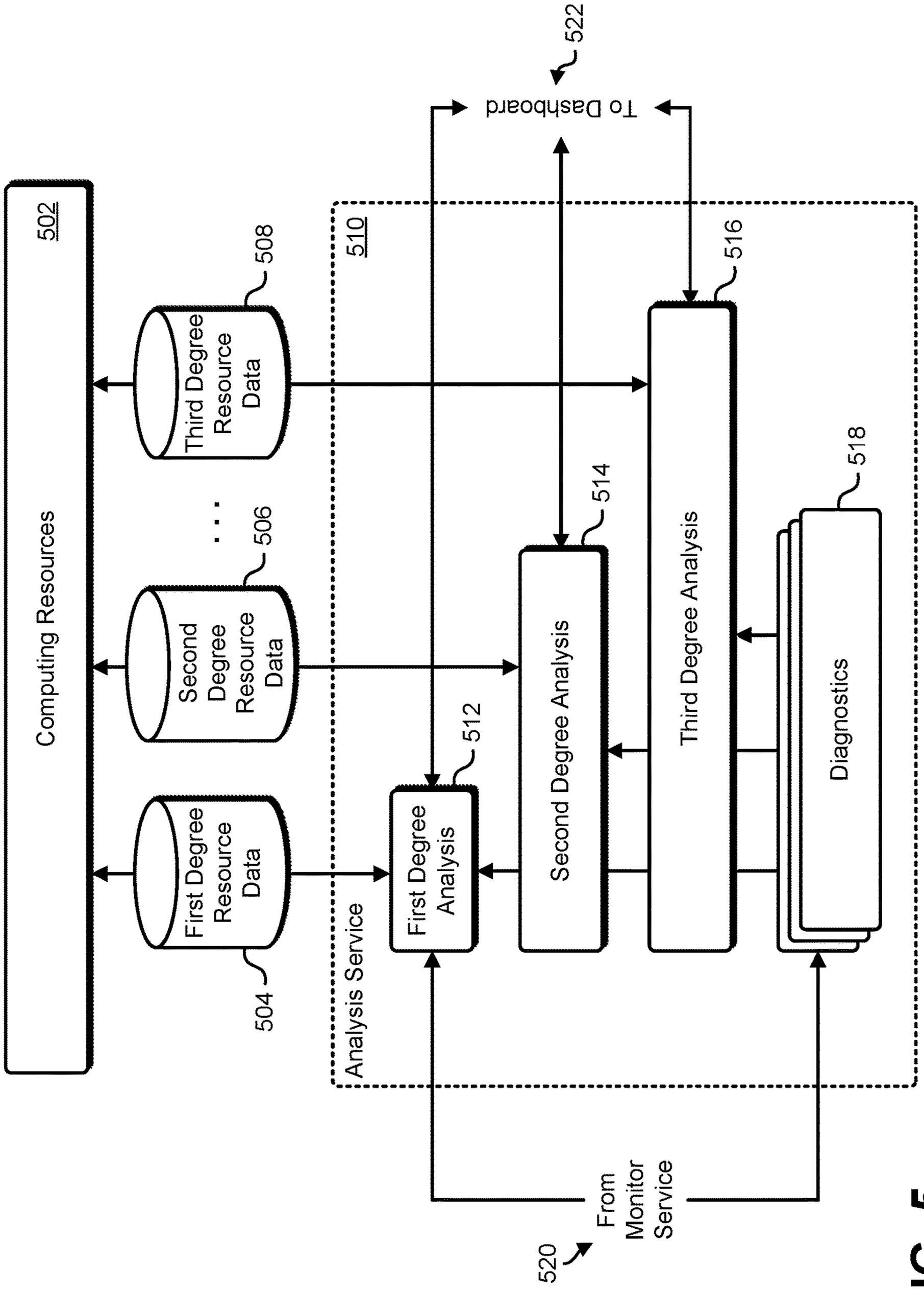
502
Computing Resources
504
First Degree Resource Data
506
Second Degree Resource Data
508
Third Degree Resource Data
510
Analysis Service
512
First Degree Analysis
514
Second Degree Analysis
516
Third Degree Analysis
518
Diagnostics
520
From Monitor Service
522
To Dashboard

FIG. 5

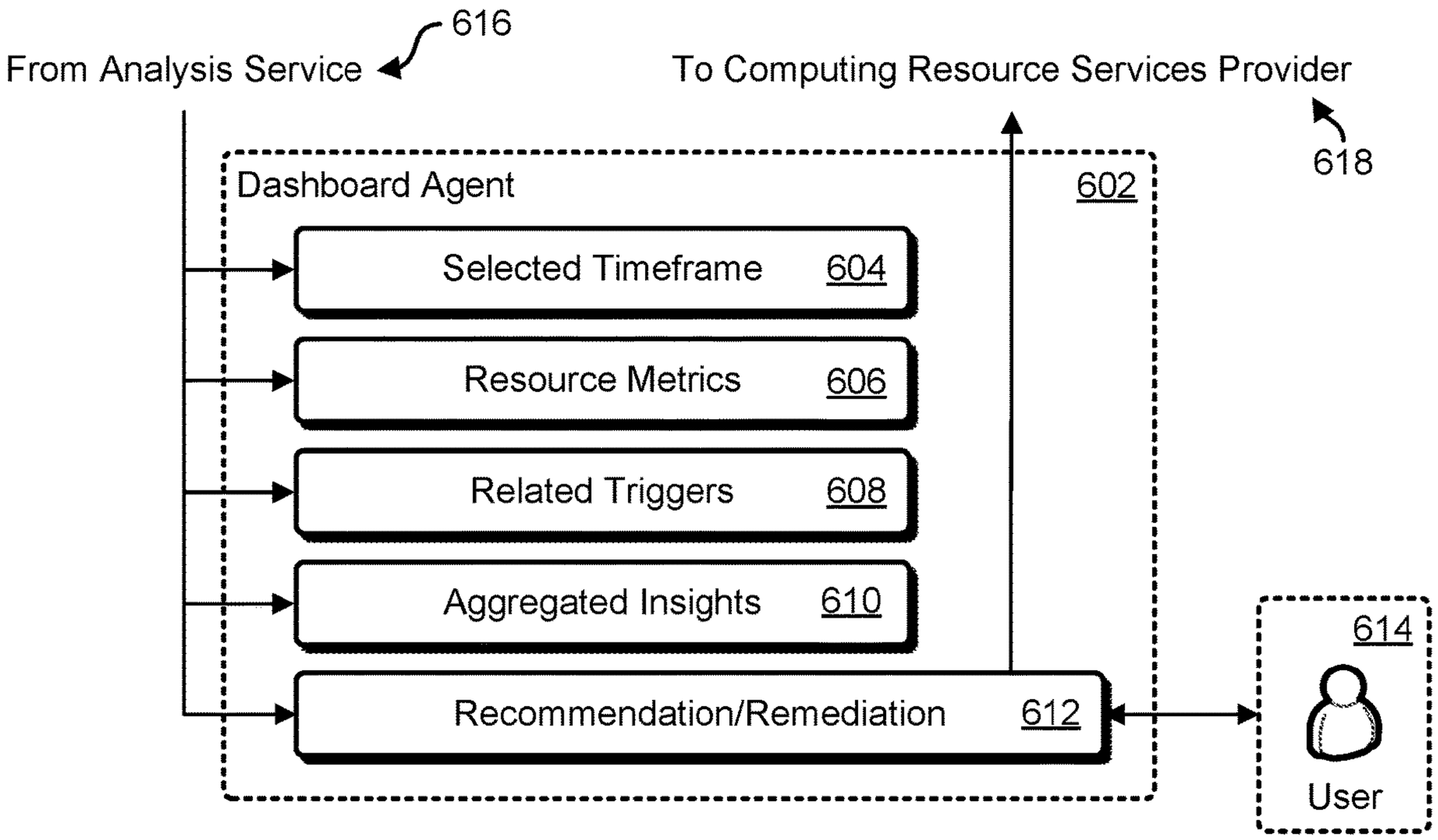
616
From Analysis Service
To Computing Resource Services Provider
618
Dashboard Agent
602
Selected Timeframe 604
Resource Metrics 606
Related Triggers 608
Aggregated Insights 610
Recommendation/Remediation 612
614
User

FIG. 6A

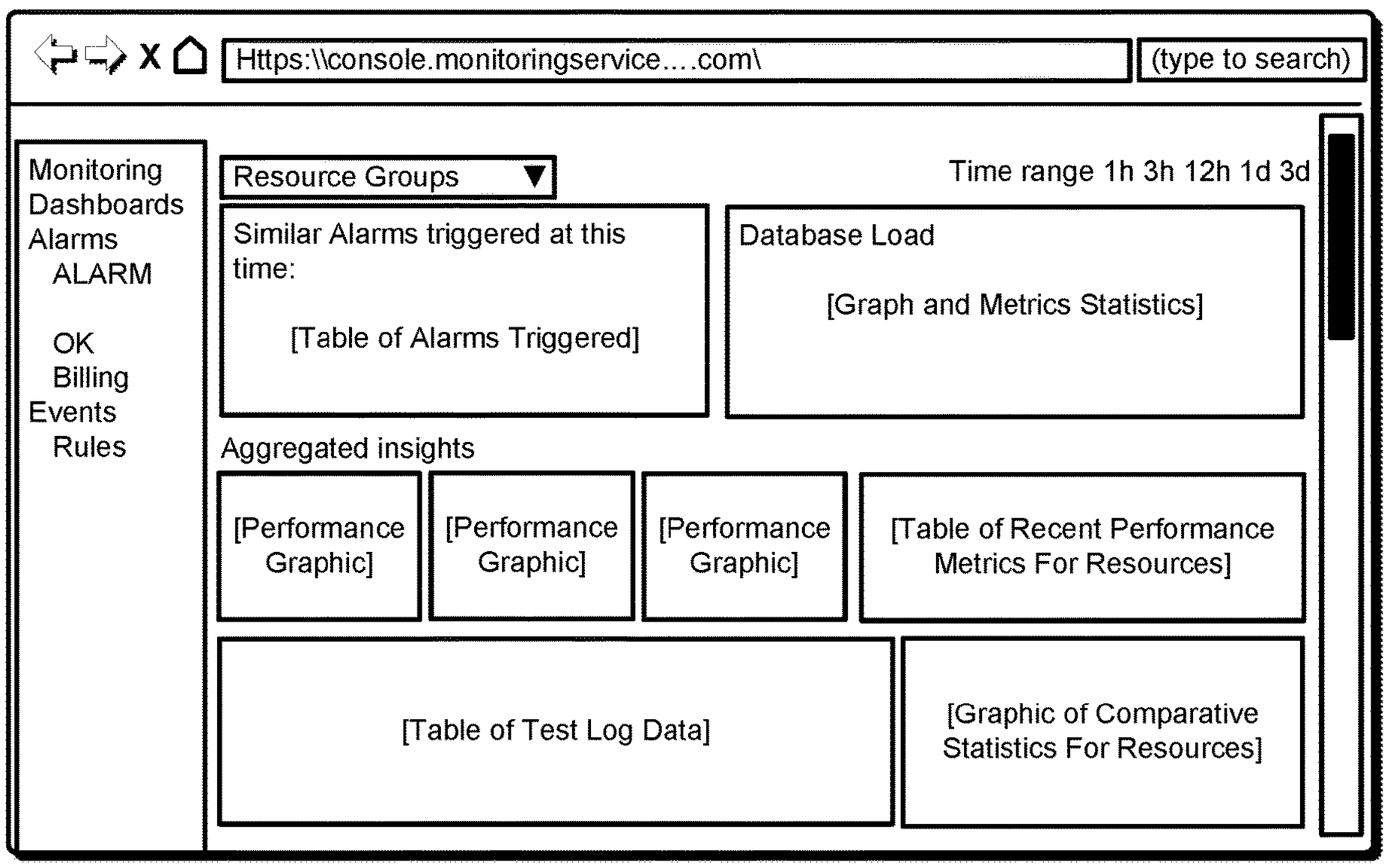
Https:\\console.monitoringservice....com\
(type to search)
Monitoring
Dashboards
Alarms
ALARM
OK
Billing
Events
Rules
Resource Groups
Time range 1h 3h 12h 1d 3d
Similar Alarms triggered at this time:
[Table of Alarms Triggered]
Database Load
[Graph and Metrics Statistics]
Aggregated insights
[Performance Graphic]
[Performance Graphic]
[Performance Graphic]
[Table of Recent Performance Metrics For Resources]
[Table of Test Log Data]
[Graphic of Comparative Statistics For Resources]

FIG. 6B

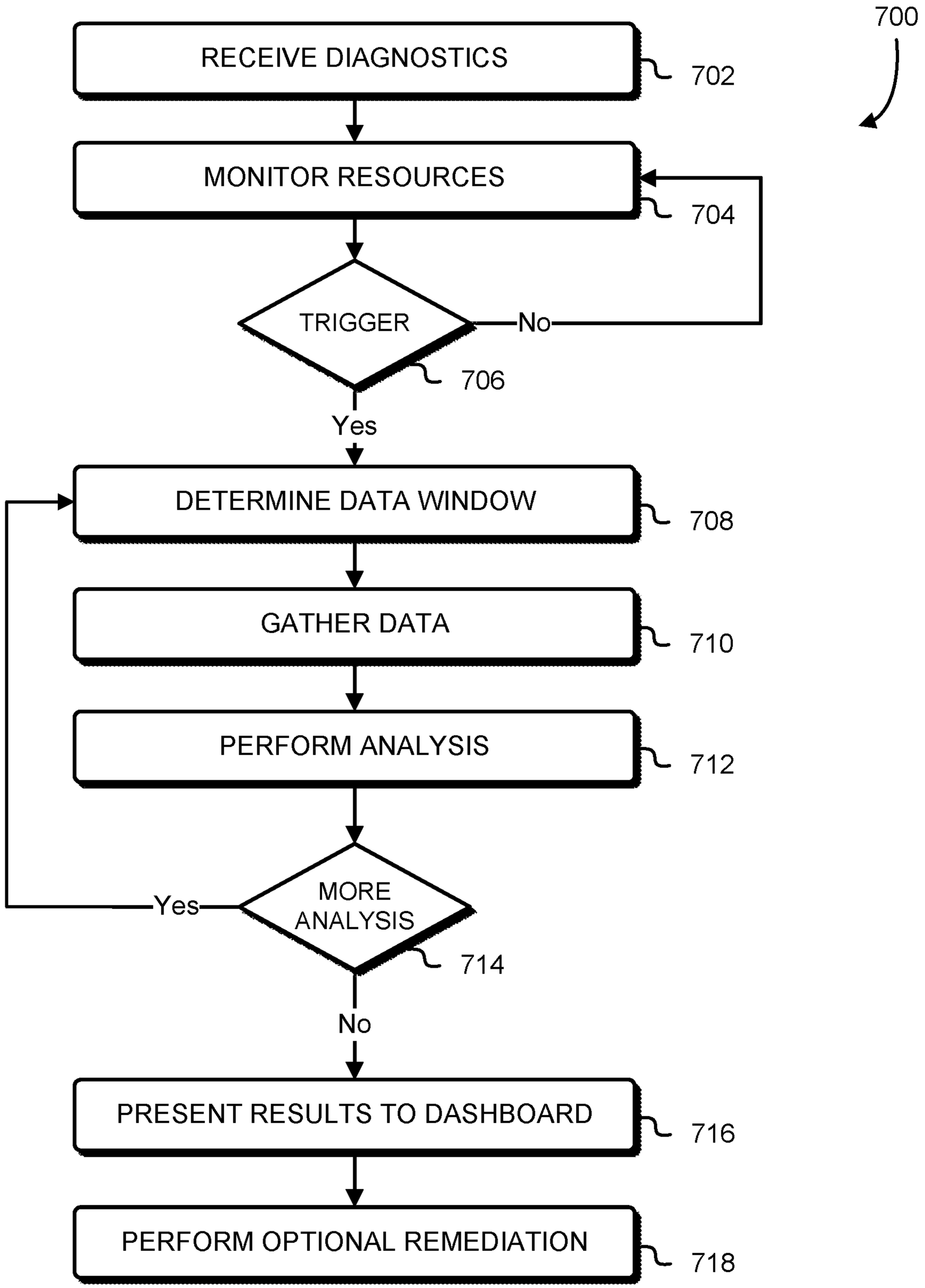
700
RECEIVE DIAGNOSTICS
702
MONITOR RESOURCES
704
TRIGGER
No
706
Yes
DETERMINE DATA WINDOW
708
GATHER DATA
710
PERFORM ANALYSIS
712
MORE ANALYSIS
Yes
714
No
PRESENT RESULTS TO DASHBOARD
716
PERFORM OPTIONAL REMEDIATION
718

FIG. 7

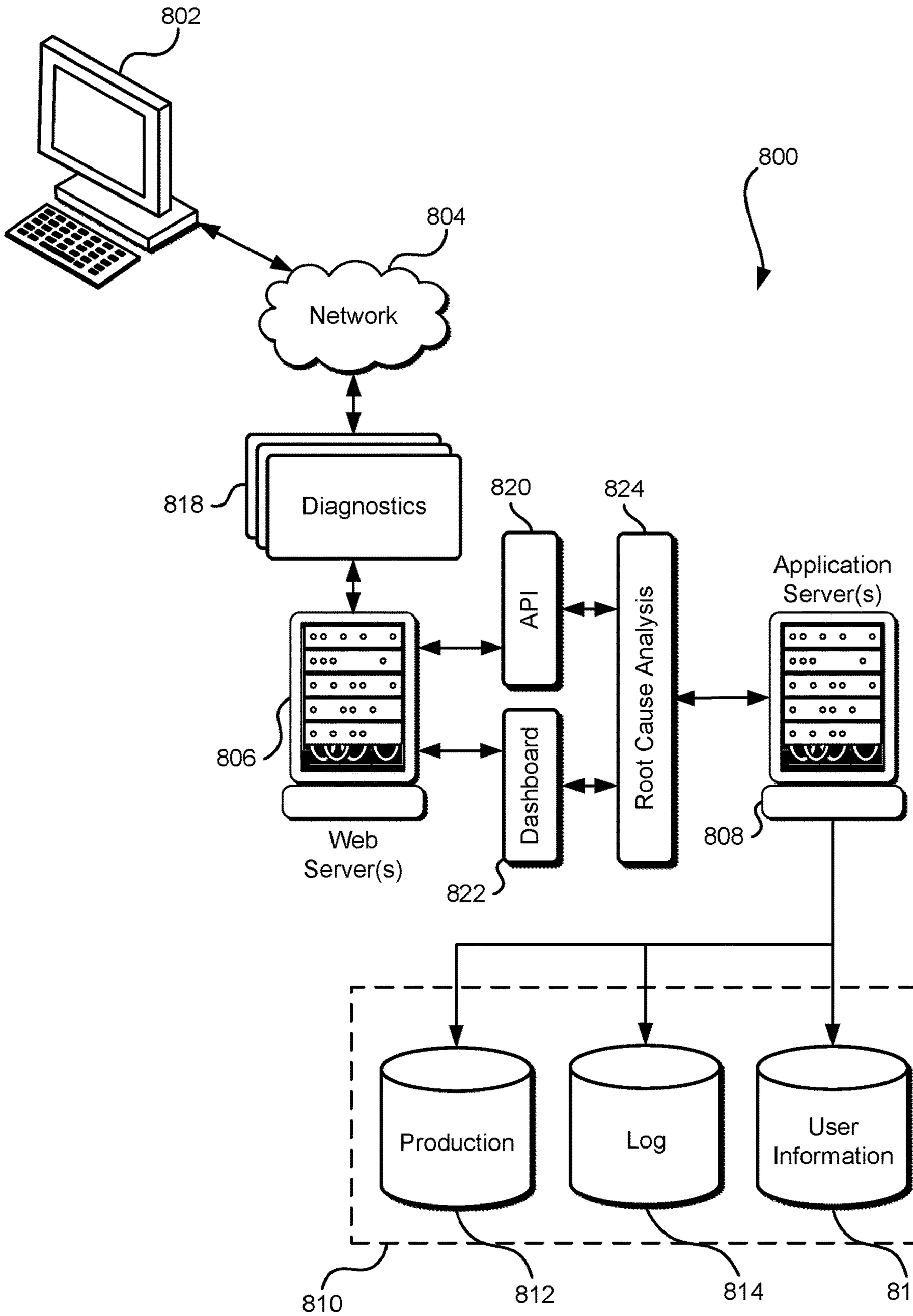
800
802
804
Network
818
Diagnostics
820
API
824
Root Cause Analysis
Application Server(s)
806
Web Server(s)
822
Dashboard
808
Production
Log
User Information
810
812
814
816

FIG. 8

# ASSISTED DETECTION OF APPLICATION PERFORMANCE ISSUES USING SERVERLESS COMPUTE TEMPLATES

## BACKGROUND

Increased availability of computing resources as a service has led to growing use of remote computing resource services providers to perform software application hosting for a plurality of user software applications. These users do not have direct physical access to and control of hardware and software resources used to facilitate hosting of their own software applications. When and if application performance issues arise, computing resource service providers generally provide access to logging and other resource usage data to facilitate determination of the cause of said performance issues. However, customers often are unable to effectively use this logging and resource usage data, and resort to use of multiple tools to get complete observability of resource use across their applications. This use of multiple tools by customers can be expensive, complex, inconsistent, and often increases mean time to resolution of application performance issues.

## BRIEF DESCRIPTION OF THE DRAWINGS

Various techniques will be described with reference to the drawings, in which:

FIG. **1** illustrates an example process for automated determination of a root cause of system and application performance problems.

FIG. **2** illustrates an example architecture for performing root cause analysis by a computing resource services provider.

FIG. **3** illustrates an example of user-defined diagnostics to facilitate root cause analysis.

FIG. **4** illustrates an example architecture for monitoring usage data of one or more computing resources based on user-defined diagnostics.

FIG. **5** illustrates an example architecture for performing one or more analysis operations of computing resource data according to user-defined diagnostics.

FIG. **6**A illustrates an example dashboard architecture to facilitate presentation of information about one or more root cause issues to a user.

FIG. **6**B illustrates an example dashboard interface using a web browser.

FIG. **7** illustrates a process for performing root cause analysis by a computing resource services provider using user-defined diagnostics.

FIG. **8** illustrates a system in which various embodiments can be implemented.

## DETAILED DESCRIPTION

The present document describes various systems and methods to facilitate identification of one or more root causes of performance issues related to applications hosted by a computing resource services provider based, at least in part, on user-supplied diagnostics. Root cause analysis identifies, in an application hosted by a computing resources services provider or any other application hosting services, one or more key issues causing a decrease in application performance or other application behavior. Root cause analysis may additionally provide suggested solutions to improve application performance or facilitate automated resolution of issues related to decreased application performance. To improve generalizability of root cause analysis to diverse applications being executed by a computing resource service provider, the platform described herein introduces user-supplied diagnostics to define key limitations and resources related to a specific application.



The user-supplied diagnostics described herein allow for application providers to indicate specific analysis operations to be performed on specific resources as well as time windows on which analysis is to be performed in order to improve mean time to resolution of application performance issues. Identification of one or more root causes related to application performance issues is accomplished, in some examples, by a platform that facilitates creation, configuration, and automation of user-supplied diagnostics to analyze performance issues related to applications and underlying computing resource infrastructure. These user-supplied diagnostics allow a root cause identification platform to collect, aggregate, and highlight key data and insights related to application performance issues.

Traditionally, customers utilize a plurality of tools to identify causes of application performance issues, such as log management tools, metrics tools, and alarm and incident management tools. This plurality of tools potentially allows users complete observability of potential causes of application performance degradation. However, customer use of a plurality of tools increases mean time to identify and resolve root causes of reduced application performance while increasing costs and complexity of root cause identification.

Root cause analysis requires identification of issues across highly distributed application infrastructure utilized by various customers, with issue patterns that may be customer specific and potentially traverse various resources of the distributed application infrastructure. In addition, customers constantly iterate on and deploy new changes to their applications and update computing resource infrastructure used. Deploying a root cause analysis solution that identifies a pattern for one application configuration may not be effective for future application deployments. Consequently, root cause analysis solutions must be able to adapt to constantly changing user application infrastructure as well as ensure that correct performance or resource data is analyzed.

In order to address complexities described above, techniques and methods described herein to perform root cause analysis rely on user-supplied diagnostics. As described above, a user has one or more applications hosted by or otherwise utilizing resources of a computing resource services provider. These applications change or iterate over time. Because of these changes over time, detection of one or more root causes of performance issues that arise due to application resources or computing resource services provider resources cannot be performed without use of multiple third-party tools. These third-party tools may not account for changes to user applications in their resource analysis. User-supplied diagnostics allow for application developers or owners to customize root cause analysis to various application iterations and resources used by those iterations.

To begin, root cause analysis performed by systems and methods described herein utilizes an application programming interface (API) provided by a computing resource services provider. This API implements or otherwise provides system calls to indicate data analysis windows, functions, and resource monitoring, or any other functionality related to root cause analysis. A user, application developer, or application owner implements one or more user-supplied diagnostics to be performed by a computing resource services provider for root cause analysis and identification of

performance degradation causes. These user-supplied diagnostics, described below in conjunction with FIG. **3**, comprise data values and software instructions implementing serverless compute functions to be performed by a serverless compute service. The user-supplied diagnostics contain data parameters and serverless compute functions used to specify what data or resources to monitor that are specifically used by an application, and what analysis operations to perform in order to identify one or more root causes of application performance degradation.

A computing resource services provider monitors computing resources indicated in the user-supplied diagnostics according to metrics also indicated in the user-supplied diagnostics. If a computing resource use passes a threshold value, or application performance degrades past a threshold value, a computing resource services provider implementing root cause analysis gathers data to perform root cause analysis. This data can correspond to a time window indicated in the user-supplied diagnostics.

Using data for a specific time window, root cause analysis on a computing resource services provider performs one or more analysis operations, which can also be indicated in user-supplied diagnostics or implemented by default by root cause analysis, in order to determine one or more root causes of application performance degradation. These analysis operations comprise at least an initial, or resource-specific analysis. Additional analysis operations may be performed as indicated by user-supplied diagnostics, as described below in conjunction with FIGS. **3** and **5**.

After one or more analysis operations are applied to data for any specific time window indicated in user-supplied diagnostics, results are presented to a dashboard. A dashboard is a web or other interface provided or presented by a computing resource services provider comprising information about resources and analysis indicated or specified in user-supplied diagnostics. The dashboard indicates a root cause of application performance issues identified by one or more analysis operations indicated in user-supplied diagnostics or otherwise performed by default in root cause analysis. Optionally, a dashboard may include suggested remediation steps to be performed that address application performance issues. A dashboard may also comprise one or more buttons or other user feedback facilities to trigger remediation steps to be performed on a computing resource services provider.

While root cause analysis of application performance issues is used extensively for the purpose of illustration, it should be noted that the techniques described herein can be adapted other uses. For example, a platform for root cause analysis using user-supplied diagnostics is usable for analysis of other application issues arising from hosting by a computing resource services provider. Identification of root causes for application security issues, for example, is improved by the techniques described herein. A user creates diagnostics related to one or more analysis operations to identify application security issues, and the platform described herein monitors one or more user applications during runtime to identify root causes of security issues related to both the applications and the computing resources used by the applications. Techniques described herein can also be adapted for resolution of application performance issues with minimal or no user interaction. That is, the platform described herein may implement automated issue resolution using user-supplied diagnostics. These user-supplied diagnostics can, in an embodiment, indicate steps to take in order to resolve commonly, or previously, encountered root causes of application performance degradation. These steps would then be performed, by the platform described herein, without user invocation and automatically as specific root causes arise.

In the preceding and following description, various techniques are described. For purposes of explanation, specific configurations and details are set forth in order to provide a thorough understanding of possible ways of implementing the techniques. However, it will also be apparent that the techniques described below may be practiced in different configurations without the specific details. Furthermore, well-known features may be omitted or simplified to avoid obscuring the techniques being described.

An embodiment illustrating steps to perform root cause analysis using the techniques and methods herein is described below in conjunction with FIG. **1**. An embodiment illustrating an architecture to perform root cause analysis is described below in conjunction with FIG. **2**. An embodiment illustrating user-supplied diagnostics is described below in conjunction with FIG. **3**. Several example embodiments to perform various steps or aspects of root cause analysis using the architecture of FIG. **2** are described below in conjunction with FIGS. **4-6**. An example process to perform root cause analysis is provided below in conjunction with FIG. **7**. For purposes of illustration regarding various embodiments further described below in conjunction with FIGS. **2-7**, a computing resource provider is interchangeable with an application hosting provider or an application execution environment. An application is interchangeable with software. A computing system is interchangeable with a computing device. A client, client computer, client device, or any other client is type or use of a computing system. A server, server computer, server device, or any other server is a type or use of a computing system. A computing system is interchangeable with computer device. A service provider is interchangeable with a computing resources service provider.

FIG. **1** illustrates an example process for automated determination of a root cause of system and application performance problems using root cause analysis **116**. Root cause analysis **116** is a process implemented in software instructions that, when executed, gather data corresponding to one or more computing resources and apply one or more analysis operations to diagnose a likely cause of application performance degradation. Root cause analysis facilitates minimal input by administrators of a computing resource provider or application developers to identify one or more causes of application degradation.

Root cause analysis **116** comprises three overall operations implemented using systems, methods, and techniques described below in conjunction with FIGS. **2** and **4-6**. First, root cause analysis **116** comprises discovery **118** operations. Discovery **118** operations are software instructions that, when executed, monitor one or more resources used by, or corresponding to, one or more applications to be monitored by a computing resource services provider.

Discovery **118** operations, described below in conjunction with FIGS. **2** and **4**, discover issues related to application performance degradation by monitoring computing resources.

Computing resources are monitored, by discovery **118** operations, using performance or resource data **102** comprising usage **104** information, traces **106**, logs **108**, alarms **110**, events **112**, notifications **114**, or any other information channels provided by a computing resource services provider. Performance data or resource data **102** represents data values comprising information about computing resources of a computing resource services provider, as further

described below in conjunction with FIG. **2**. Performance or resource data **102** comprises, in an embodiment, usage **104** information. Usage **104** information represents one or more data values indicating metrics or other numerical values associated with one or more computing resources. Performance or resource data **102** comprises, in an embodiment, traces **106**. Traces **106** are data values comprising information about application execution or resource service execution, in an embodiment. In another embodiment, traces **106** comprise instructions executed and stored in memory associated with an application or service of a computing resource services provider.

Performance or resource data **102**, in an embodiment, comprises logs **108**. Logs are data values comprising recordings, console output, or any other metadata or information generated by applications or services performed by a computing resource services provider. Performance or resource data **102**, in an embodiment, comprises alarms **110**. Alarms **110** are data values comprising indications generated by a service of a computing resource services provider, in an embodiment. Performance or resource data **102**, in an embodiment, comprises events **112**. Events **112** are data values comprising one or more indications that an application or service has performed or encountered an operation, in an embodiment. Performance or resource data **102** comprises, in an embodiment, notifications **114**. Notifications **114**, in an embodiment, are data values comprising an indication that are triggered by an application or service performed by a computing resource services provider based on a condition, in an embodiment. Discovery **118** operations, in an embodiment, utilize any other information about resources provided by or associated with one or more services of a computing resource services provider.

A user of root cause analysis **116** provides user-supplied diagnostics, implemented as serverless compute functions. Serverless compute functions, in an embodiment, are collections of software instructions implementing a function that are performed by a serverless computing service of a computing resource services provider. These user-supplied diagnostics, described below in conjunction with FIGS. **2** and **3**, indicate resources to be monitored by discovery **118** operations. Discovery **118** operations then utilize facilities provided by a computing resource services provider to identify anomalous use of specific computing resources. For example, discovery **118** operations monitor memory use associated with an application by using memory information related to overall or application-specific use by a computing resource services provider.

Root cause analysis **120** comprises diagnosis **120** operations. Diagnosis **120** operations are software instructions that, when executed, perform one or more default or user-specified analysis operations on a set of data associated with one or more applications being performed by a computing resource services provider, as further described below in conjunction with FIG. **5**. Analysis operations, in an embodiment, are operations that perform queries, filtering, reduction, identification, or any other operations on a set of data in conjunction with or generated by one or more applications being performed by a computing resource services provider. Analysis functions are, in an embodiment, groups of analysis operations to perform queries, filtering, reduction, identification, or any other operations on a set of data in conjunction with or generated by one or more applications being performed by a computing resource services provider. Diagnosis **120** operations operate by first gathering data associated with degradation of application performance, and second, applying one or more analysis operations or functions to gathered data in order to identify one or more causes of degraded application performance. Data is gathered specific to computing resources indicated by user-supplied diagnostics, described below in conjunction with FIG. **3**. The amount of data gathered for each computing resource is indicated by a time window, also specified in user-supplied diagnostics.

Diagnosis **120** operations then apply one or more analysis operations or functions on gathered data. These analysis operations or functions may be default analysis operations or functions specific to a given computing resource. Default analysis operations or functions are defined by a system implementing root cause analysis **116** and are not specified or implemented by a user in user-supplied diagnostics. Analysis operations or functions may also be user-supplied analysis operations or functions. User-supplied analysis operations or functions are defined in user-supplied diagnostics and use an application programming interface (API) provided by a computing resource services provider in order to facilitate identification of computing resource problems specific to an application. User-supplied analysis operations or functions comprises analysis operations or functions specific to a computing resource. User-supplied analysis operations or functions may also comprise analysis operations or functions specific to an abstraction of a computing resource, such as a grouping with related resources or a grouping with all other resources utilized by an application. Diagnosis **120** operations apply one or more analysis operations or functions to one or more sets of gathered data corresponding to one or more computing resources, and generate data indicating information about one nor more causes of application performance degradation.

Root cause analysis **116** also comprises resolution **122** operations. Resolution **122** operations are software instructions that, when executed, present root cause information identified by diagnosis **120** operations to one or more users. After diagnosis **120** operations identify one or more root causes of application performance degradation, resolution **122** operations present that information to one or more responsible parties able to perform remediation. Resolution **122** operations comprise at least an interface for displaying results from one or more analysis operations or functions performed during diagnosis **120**. This interface may be a web interface, data stream, information feed, or any other technique for communication data or other information by a computing resource services provider. For example, an interface for presenting data related to one or more analysis operations or functions performed during diagnosis **120** is a web dashboard displaying reports of resource usage during specific time windows, as used by an application.

Resolution **122** or remediation operations may also comprise facilities to manage automated resolution of one or more issues identified by diagnosis **120** operations. These resolution operations are software instructions defined by a user in user-supplied diagnostics that, when executed, automatically resolve application performance issues for one or more identified causes. Resolution or remediation operations are, in another embodiment, software instructions defined by a computing resource service provider that, when executed, resolve frequent or easily resolved application performance issues related to one or more computing resources. Performance issues, in an embodiment, are indications of reduced performance corresponding to one or more computing resources determined from performance data, as described below in conjunction with FIG. **2**. Resolution operations are optional and not required to perform root cause analysis **116**. However, systems, methods, or techniques further described

herein to perform root cause analysis **116** facilitate automated resolution of one or more causes of application performance degradation through user-supplied diagnostics comprising automated resolution instructions.

FIG. **2** illustrates an example architecture for performing root cause analysis by a computing resource services provider **202**. A computing resource services provider **202** is a platform comprising one or more computing resources **204** provided as a service, as further described herein. A computing resource services provider facilitates application hosting using one or more computing resources **202** during application execution. Computing resources **204** are hardware and software components and resources provided by a computing resource services provider further described herein to perform software application hosting and execution services. During application execution, one or more computing resources **204** may cause application performance degradation. If application performance degrades, a computing resource services provider **116** performs or otherwise facilities root cause analysis to determine one or more causes of reduced application performance, as described above in conjunction with FIG. **1**.

A user **220** facilitates root cause analysis for one or more applications by creating or otherwise providing diagnostics **218**. A user **220** is an application developer, application creator, application owner, or other entity associated with one or more software applications being hosted or otherwise executed by a computing resource services provider **202**. A user **220** is, in an embodiment, a system administrator or development operations (DevOps) engineer associated with a computing resource services provider **202**. A user **220** is, in another embodiment, an application or software developer, a DevOps engineer, system administrator, or other entity associated with an application being hosted or otherwise executed using a computing resource services provider **202**.

To perform root cause analysis using a computing resource services provider **202**, a user **220** authors or otherwise provides diagnostics **218** implemented using serverless compute functions. Serverless compute functions are collections of software instructions to be performed by a serverless computing service **224** in a computing resource services provider. A serverless compute service **224** is, in an embodiment, data values and software instructions usable by a computing resource services provider to perform a computing service. A serverless compute service executes or otherwise runs user software applications or serverless compute functions, such as those implementing diagnostics **208**, using computing resources **204** of a computing resource services provider **202**. Serverless compute functions implementing diagnostics **218** comprise, in an embodiment, data values and/or software instruction to specify how root cause analysis is to be performed by a computing resource services provider **202**. Serverless compute functions implementing diagnostics **218** comprise, in an embodiment, data values and/or software instructions to indicate one or more diagnostics provided by a computing resource services provider **202** to be utilized during root cause analysis. Serverless compute functions implementing diagnostics **218** may also comprise software instructions implementing one or more user-supplied analysis operations or functions to be performed during root cause analysis. Serverless compute functions implementing diagnostics **218** comprise data values or parameters indicating computing resources **204** to be monitored, time windows on which to perform one or more analysis operations or functions specified by one or more software instructions in said diagnostics **218**, or other data values to facilitate root cause analysis by a computing resource services provider **202**. Software instructions and/or data values provided in serverless compute functions implementing diagnostics **218**, by a user **220**, utilize an application programming interface (API) provided by a computing resource services provider **202**, as described below in conjunction with FIGS. **4** and **8**.

A computing resource services provider **202** comprises one or more software and/or hardware modules or components to perform steps of root cause analysis described above in conjunction with FIG. **1**. To perform or otherwise facilitate root cause analysis, a computing resource services provider **202** comprises data values and/or software instructions that, when executed, perform discover **206**, diagnosis **210**, and resolution **214** in conjunction with one or more user **220** applications and user-supplied diagnostics **218**.

To perform discovery **206**, as described above in conjunction with FIG. **1**, a computing resource services provider **202** comprises a monitor service **208** using a computing resource monitoring service **222**. A computing resource monitoring service **222** is a service provided by a computing resource services provider **202**, in an embodiment, where performance or resource data is collected by said computing resource monitoring service about one or more computing resources **204**. A monitor service **208** performs performance monitoring. Performance monitoring is identification of one or more aspects of one or more computing resources **204** related to use or performance of those one or more computing resources **204** provided by a computing resource monitoring service **222**. Performance monitoring, in an embodiment, detects application performance degradation using performance data. Performance data, in an embodiment, is data collected by a computing resource monitoring service **222** or other service of a computing resource services provider **202**. In another embodiment, performance data is log data generated by one or more software applications performed by or using resources **204** of a computing resource services provider **202**. Performance data, in an embodiment, comprises one or more usage values. Usage values are, in an embodiment, data values indicating usage of one or more computing resources **204** by a computing resource monitoring service **222** or other service of a computing resource services provider **202**. Performance data, in an embodiment, is associated with a time value. A time value is a data value indicating a time during which or at which one or more items of performance data were generated, created, received, or otherwise obtained. A computing resource monitoring service **222** receives, in an embodiment, one or more triggers indicating application performance degradation. A trigger or triggering event is an indication that one or more performance thresholds have been violated. A performance threshold, in an embodiment, is one or more numerical values indicating upper or lower limits on computing resource **204** use or performance. A performance threshold is violated if computing resource **204** use or performance meets and/or exceeds the one or more numerical values indicating upper limits on use or performance of the computing resource **204**, in an embodiment. In another embodiment, a performance threshold is violated if computing resource **204** use or performance meets and/or falls below the one or more numerical values indicating lower limits on use or performance of the computing resource **204**. If a performance threshold for one or more computing resources is violated, those computing resources have degraded performance, in an embodiment. In an embodiment, degraded performance indicates that computing resource **204** use or performance meets and/or exceeds

a performance threshold. In another embodiment, degraded performance indicates that computing resource **204** use or performance meets and/or falls below a performance threshold. A monitor service **208**, in an embodiment, is data values and/or software instructions that, when executed, monitor one or more computing resources **204** associated with one or more user **220** applications as indicated by user-supplied diagnostics **218**. A monitor service **208**, in an embodiment, utilizes a computing resource monitoring service **222** to observe, monitor, record, or otherwise access data and/or metrics about one or more computing resources **204**. A monitor service **208**, in an embodiment, provides or otherwise utilizes an API to a computing resource monitoring service **222** to indicate one or more computing resources **204** to be monitored. A monitor service **208** determines one or more computing resources **204** to monitor for anomalous activity or activity that may degrade performance of one or more software applications based, at least in part, on diagnostics **218**. Diagnostics **218**, described above and below in conjunction with FIG. **3**, are received by a monitor service **208** or other component of a computing resource services provider **202** from a user **220**.

A monitor service **208** performs diagnostics on, or otherwise monitors, one or more computing resources **204** provided by a computing resource services provider **202**. A monitor service **208** utilizes performance data about one or more computing resources **204**, such as alarms, events, messages, and other information generated by a computing resource services provider **202** implementing a computing resource monitoring service **222** to observe or otherwise monitor one or more computing resources **204**. If, in an embodiment, performance data indicates application use or consumption of one or more computing resources increases past a performance threshold value, or decreases below a performance threshold value, indicated in diagnostics **218**, a monitoring service **208** indicates a triggering event and a computing resource services provider **202** begins diagnosis **210**. In another embodiment, if a monitor service **208** determines, using performance data, that application performance degrades past a performance threshold value indicated in diagnostics **218**, a computing resource services provider **202** begins diagnosis **210**. If a monitor service **208** utilizing a computing resource monitor service **222** indicates a triggering event, the computing resource monitoring service **222**, in an embodiment, invokes one or more serverless compute service **224** operations such as those performed by an analysis service **212**.

To perform diagnosis **210**, as described above in conjunction with FIG. **1**, a computing resource services provider **202** further comprises an analysis service **212**. An analysis service **212**, in an embodiment, is data values and/or software instructions that, when executed, gather data and metrics relevant to one or more analysis operations or functions to be performed, and perform said analysis operations or functions. An analysis service **212**, in an embodiment, is performed by a computing resource services provider **202** using a serverless compute service **224** in response to a triggering event by a monitor service **208**. In another embodiment, an analysis service **212** is performed by a computing resource services provider **202** using a serverless compute service **224** in response to a request by a user **220**.

A serverless compute service **224** is, in an embodiment, data values and software instructions usable by a computing resource services provider **202** to perform a computing service. A serverless compute service **224** executes or otherwise runs user software applications or other user code using computing resources **204** of a computing resource services provider **202**. A serverless compute service **224**, in an embodiment, executes one or more sets of software instructions from user-supplied diagnostics **218**. In an embodiment, a serverless compute service **224** supports one or more sets of software instructions implemented using one or more software programming languages described herein. A serverless compute service **224** performs cloud functions to facilitate interaction between one or more software programs executed by a serverless compute service **224** and one or more other services implemented by a computing resource services provider **202**, such as a computing resource monitoring service **222**.

A serverless compute service **224** comprises one or more software programs implemented or otherwise defined in user-supplied diagnostics **218**, in an embodiment. In another embodiment, a serverless compute service **224** comprises one or more software programs transferred to a computing resource services provider **202** over a network. In another embodiment, a serverless compute service **224** comprises utilities to author or otherwise create one or more software programs to be executed by said serverless compute service **224**.

A serverless compute service **224** receives, in an embodiment, triggers from one or more other services of a computing resource services provider **202**. A trigger is an indication that one or more performance thresholds have been violated, as described above. A serverless compute service **224** executes one or more software programs upon receiving one or more triggers or indications from one or more other services provided by a computing resource services provider. For example, a computing resource monitoring service **222** indicates or otherwise triggers a serverless compute service **224** when computing resource **204** use passes a performance threshold, and the serverless compute service **224** executes or otherwise runs one or more software analysis operations or functions defined or implemented in user-supplied diagnostics **218**, as described herein.

An analysis service **212**, further described below in conjunction with FIG. **5**, performs one or more analytical techniques to determine one or more root causes of application performance degradation. An analysis service **212** comprises multi-level diagnostic or analysis operations and/or functions. One or more users **220** determine, by indicating in diagnostics **218**, which diagnostic or analysis operations and/or functions are to be performed during root cause analysis by a computing resource services provider **202**.

Analysis operations and/or functions to be performed by an analysis service **212** hosted or otherwise performed by a computing resource services provider **202** comprise multiple levels. First degree analysis operations and/or functions focus on a time window or time slice, as well as resource-specific data, as indicated in user-supplied diagnostics. Second degree analysis operations and/or functions focus on examining dependent computing resources **204** to those computing resources **204** indicated or implicated by first degree analyses. Third degree analysis operations and/or functions focus on specific computing resource **204** groups implicated by first and second degree analysis operations and/or functions. Additional analytical abstractions may be provided by a user **220** through user-supplied diagnostics **218** that further abstract into a broader window of computing resources for analysis. One or more analysis operations and/or functions having one or more degrees or levels are performed by an analysis service **212** to facilitate diagnosis **210** of one or more root cause issues impacting application performance. Once those root cause issues are identified, a

dashboard agent **216** facilitates communication of those issues to a user **220** for resolution **214**.

To perform resolution **214**, as described above in conjunction with FIG. **1**, a computing resource services provider **202** comprises a dashboard agent **216**. A dashboard agent **216** is data values and/or software instructions that, when executed by a computing resource services provider, present information related to one or more root cause issues identified by an analysis service **212**. A dashboard agent **216**, in an embodiment, comprises a dashboard interface to present data related to one or more root cause issues. A dashboard interface is, in an embodiment, a user interface usable to present data related to one or more root cause issues. In an embodiment, a dashboard interface is a web interface. A web interface, in an embodiment, is a user interface presented by an Internet browser or otherwise presentable over a network by a computing resource services provider or a frontend associated with a service of a computing resource services provider. In another embodiment, a dashboard agent **216** comprises generated reports to be transmitted or otherwise communicated to one or more users **220**.

A dashboard agent **216** generates visual representations, such as graphs, of data associated with one or more root cause issues identified by an analysis service **212** performed by a computing resource services provider **202**. In an embodiment, a dashboard agent **216** provides user-feedback mechanisms to receive user **220** input associated with one or more analysis operations or functions performed by an analysis service **212**. In another embodiment, a dashboard agent **216** receives user input to perform one or more groups of software instructions to remediate one or more issues identified by a computing resource services provider **202** during root cause analysis. Software instructions to remediate one or more issues identified by a computing resource services provider **202** during root cause analysis are, in an embodiment, determined by or provided by said computing resource services provider **202** to remediate common causes of application performance degradation. In another embodiment, software instructions to remediate one or more issues identified by a computing resource services provider **202** during root cause analysis are provided by a user **220** through diagnostics **218**.

FIG. **3** illustrates an example of user-defined diagnostics **302** to facilitate root cause analysis, as described above. Diagnostics **302** are data values and/or software instructions to define parameters and analysis operations and/or functions to be performed by a computing resource services provider during root cause analysis. Diagnostics **302** are curated, or user-defined and/or supplied by one or more users as described above in conjunction with FIG. **2**. Diagnostics **302** comprise software instructions implementing serverless compute functions performing application programming interface (API) calls to configure, define, or otherwise organize parameters **304** and templates **306** associated with root cause analysis performed by a serverless compute service of a computing resource services provider.

Diagnostics **302** comprise parameters **304**. Parameters **304** are data values usable to configure root cause analysis by a computing resource services provider. Parameters **304** define computing resources to be monitored by a computing resource services provider. Parameters **304** also define time slices or time windows used to narrow down data pools related to computing resources to be analyzed by a computing resource services provider. Parameters **304**, in an embodiment, indicate one or more analysis operations and/or functions provided by a computing resource services provider to perform root cause analysis. In another embodiment, parameters **304** indicate one or more remediation operations or techniques provided by a computing resource services provider to fix or otherwise address root cause issues related to application performance degradation. Remediation operations, in an embodiment, are software instructions that, when executed or otherwise performed by a computing resource services provider, make one or more changes to an application or computing resources used by an application in order to increase or decrease use or performance in conjunction with a performance threshold, as described above.

Diagnostics **302**, in an embodiment, comprise templates **304**. Templates **304** are software instructions implementing serverless compute functions, where those serverless compute functions are usable to perform one or more analysis operations or functions, or one or more remediation operations or functions, by a serverless compute service of a computing resource services provider during root cause analysis, as described above in conjunction with FIG. **2**. Templates **304** implementing serverless compute functions comprise, in an embodiment, API function calls to one or more APIs provided by a computing resource services provider. In another embodiment, templates **304** implementing serverless compute functions comprise software instructions to manipulate, analyze, or otherwise use data provided by a computing resource services provider.

Templates **306** implement one or more analysis operations or functions usable to facilitate root cause analysis by a computing resource services provider. One or more analysis operations or functions specified, defined, or otherwise implemented in templates **306** are specific to one or more user applications, in an embodiment. In another embodiment, one or more analysis operations or functions specified, defined, or otherwise implemented in templates **306** perform general analysis related to one or more computing resources provided by a computing resource services provider. One or more analysis operations or functions specified, defined, or otherwise implemented in templates **306** utilize one or more API calls provided by a computing resource services provider.

Templates **306**, in an embodiment, implement one or more remediation techniques usable to fix or otherwise alleviate application performance degradation without further user input. Remediation operations specified, defined, or otherwise implemented in templates **306** are specific to issues that cause performance degradation in a user application, in an embodiment. Remediation operations specified, defined, or otherwise implemented in templates **306**, in another embodiment, are specific to general performance degradation issues related to computing resources in a computing resource services provider.

One or more templates **306** indicated in diagnostics **302** are organized, in an embodiment, into a hierarchy comprising degrees **308**, **310**, **312**, **314** of analysis or remediation. First degree **308** analysis or remediation operations are specific to a time window or time slice indicated in parameters **304** of diagnostics **302**, or specific to computing resources indicated by parameters **304** or otherwise by diagnostics **302**. For example, first degree **303** analysis or remediation operations may focus on specific memory configurations associated with a user application. Second degree **310** analysis or remediation operations are specific to resources dependent to those specified in the first degree **308** category. For example, analysis or remediation operations for databases and/or computing servers providing resources specified in the first degree **308** category are organized as second degree **310** analysis or remediation templates **306**.

Third degree **312** analysis or remediation operations are specific to resource groups or application groups to which computing resources associated with first **308** and second **310** degree analysis or remediation operations belong. For example, server clusters or network clusters comprising computing resources providing database, computation, memory, or other resources analyzed by first **308** and second **310** degree analysis or remediation templates **306** are categorized as third degree **312**. In addition to three degrees **308**, **310**, **312** of categorization for templates **306**, further abstraction of computing resources utilized for analysis and/or remediation by templates **306** is categorized up to an $n^{th}$ degree **314** of grouping. Categorization or grouping up to an $n^{th}$ degree **314** is specified by a user, as described above in conjunction with FIG. **2**.

FIG. **4** illustrates an example architecture for monitoring performance or resource data **404** of one or more computing resources **402** based on user-defined diagnostics **418**. A monitor service **412**, as described above in conjunction with FIG. **2**, receives diagnostics **418**, as described above in conjunction with FIGS. **2** and **3**, from a user **420**. Diagnostics **418** utilize an application programming interface (API) **416** provided by a monitor service **412** or generally by a computing resource services provider to indicate one or more computing resources **402** to be monitored by monitor operations **414** of said monitor service **412**.

Diagnostics **418** define or otherwise indicate, as parameters or by API **416** calls, one or more computing resources **402**. A monitor service **412** receives data **406**, **408**, **410**, as described above in conjunction with FIG. **1**, indicating current usage associated with one or more computing resources **402** indicated or otherwise defined by user-supplied diagnostics **418**. A monitor service **412** requests specific performance or resource data **404** for each computing resource **402** indicated by user-supplied diagnostics **418**.

While an application is hosted, performed, or otherwise executed by a computing resource services provider, computing resources **402** associated with that application, as indicated by diagnostics **418**, are monitored by monitor operations **414** of a monitoring service **412**. Monitor operations **414** used by a monitoring service **412** are software instructions that, when executed, observe one or more data items **406**, **408**, **410** indicating information about computing resources, described above in conjunction with FIG. **1**. If performance or resource data **404** indicates computing resource **402** use or other information indicating degraded application performance, as specified by diagnostics **418**, a monitor raises an indication to an analysis service **422**, described above in conjunction with FIG. **2** and below in conjunction with FIG. **5**.

Degraded application performance or computing resource **402** usage is indicated by one or more threshold values. One or more threshold values, in an embodiment, are predetermined by a computing resource services provider implementing or otherwise performing root cause analysis. In another embodiment, one or more threshold values are defined or otherwise provided by user-supplied diagnostics, including threshold values specific to one or more computing resources **402** used by one or more specific user applications. When a threshold computing resource data **406**, **408**, **410** is observed or monitored by monitor operations **414** of a monitor service **412**, an indication is made to an analysis service **422** to perform one or more analysis operations or functions defined by user-supplied diagnostics **418** or otherwise provided by root cause analysis performed or implemented by a computing resource services provider.

FIG. **5** illustrates an example architecture for performing one or more analysis **512**, **514**, **516** operations of computing resource **502** data **504**, **506**, **508** according to user-defined diagnostics **518**. An analysis service **510**, as described above in conjunction with FIG. **2**, receives from a monitor service **520**, an indication to perform one or more analysis **512**, **514**, **516** operations as a result of a threshold value being observed indicating computing resource **502** usage causing degraded application performance. An analysis service **510** receives user-supplied diagnostics **518** from a monitor service **520** comprising one or more analysis **512**, **514**, **516** techniques to be performed. An analysis service **510**, in an embodiment, uses performance or resource data **504**, **506**, **508** comprising information about one or more computing resources **502**. Performance or resource data **504**, **506**, **508** comprises first degree performance or resource data **504**. First degree performance or resource data **504**, in an embodiment, is data comprising information associated with computing resources **502** to be analyzed by first degree analysis **512** operations, as described below. Performance or resource data **504**, **506**, **508** comprises second degree performance or resource data **506**. In an embodiment, second degree performance or resource data **506** is data comprising information associated with one or more computing resources **502** to be analyzed by second degree analysis **514** operations, as described below. Performance or resource data **504**, **506**, **508** comprises third degree performance or resource data **508**. In an embodiment, third degree performance or resource data **508** is data comprising information associated with one or more computing resources **502** to be analyzed by third degree analysis **516** operations, as described below. In another embodiment, performance or resource data **504**, **506**, **508** comprises data associated with one or more computing resources **502** usable by additional $n^{th}$ degree analysis operations and/or functions, as described above in conjunction with FIG. **3**.

An analysis service **510**, upon indication by a monitor service **520**, gathers computing resource **502** data **504**, **506**, **508** according to resources indicated by user-supplied diagnostics **518**. In an embodiment, an analysis service **510** gathers computing resource **502** data **504**, **506**, **508** for a time slice or time window indicated, defined, or otherwise specified by user-supplied diagnostics **518**. For example, if user-supplied diagnostics **518** indicate a time slice or time window of one hour, computing resource **502** data **504**, **506**, **508** comprising information related to a previous hour are gathered by an analysis service **510**. In another embodiment, an analysis service **510** gathers computing resource **502** data **504**, **506**, **508** for a time slice or time window predetermined by a computing resource services provider implementing or otherwise performing root cause analysis, where said time slice or time window is specific to an effective or representative amount of computing resource **502** data **504**, **506**, **508** usable for performing one or more analysis **512**, **514**, **516** techniques to determine a root cause of application performance degradation. In another embodiment, an analysis service **510** gathers computing resource **502** data **504**, **506**, **508** using any other method or technique to indicate a subset of computing resource **502** data **504**, **506**, **508** to be analyzed by an analysis service **510**.

Once an analysis service **510** has gathered computing resource **502** data **504**, **506**, **508** according to user-supplied diagnostics **518** or predetermined time slices or time windows determined by a computing resource services provider implementing or otherwise performing root cause analysis, said analysis service **510** performs one or more analysis operations or functions **512**, **514**, **616** on said computing

resource **502** data **504**, **506**, **508**. One or more analysis **512**, **514**, **516** techniques or operations to perform root cause analysis in order to identify one or more causes of application performance degradation are, in an embodiment, predetermined or predefined by a computing resource services provider implementing or otherwise performing root cause analysis. In another embodiment, one or more analysis **512**, **514**, **516** techniques or operations to perform root cause analysis in order to identify one or more causes of application performance degradation are defined by one or more users in user-supplied diagnostics **518**, as described above in conjunction with FIGS. **2** and **3**.

An analysis service **510** performs one or more degrees of analysis **512**, **514**, **516**, as described above in conjunction with FIGS. **2** and **3**. An analysis service **510** performs at least one or more first degree analysis **512** operations and/or functions. As described above, first degree analysis **512** operations and/or functions are analysis operations or comprise analysis operations specific to one or more computing resources **502** used by an application having degraded application performance as indicated in user-supplied diagnostics **518** or determined, by a computing resource services provider, to commonly cause degraded application performance by applications hosted or otherwise performed by said computing resource services provider.

In addition to one or more first degree analysis **512** operations and/or functions, an analysis service **510** performs, in an embodiment, one or more second degree analysis **514** operations and/or functions. In another embodiment, an analysis service **510** performs no second degree analysis **514** operations and/or functions, due to identification of a root cause of application performance degradation by first degree analysis **512** operations and/or functions or by an analysis service having no available second degree analysis **514** operations and/or functions, such as when no second degree analysis **514** operations and/or functions are provided by user-supplied diagnostics or a computing resource services provider performing or otherwise implementing root cause analysis has no second degree analysis **514** operations and/or functions to perform. Third degree analysis **516** operations and/or functions, either from user-supplied diagnostics **518** or by a computing resource services provider implementing or otherwise performing root cause analysis, are performed, in an embodiment, to facilitate detection of one or more root causes of application performance degradation. In another embodiment, no third degree analysis **516** operations and/or functions are performed.

If one or more first degree analysis **512** operations and/or functions identify a root cause, in an embodiment, information related to computing resources **502** and computing performance or resource data **504**, **506**, **508** is provided, by an analysis service **510**, to a dashboard **522**. If one or more first degree analysis **512** operations and/or functions are unable to determine a root cause of application performance degradation, in an embodiment, information related to computing resources **502** and computing performance or resource data **504**, **506**, **508** determined by one or more second degree analysis **514** operations and/or functions is provided, by an analysis service **510**, to a dashboard **522**. If one or more first degree analysis **512** operations and one or more second degree analysis **514** operations and/or functions are unable to determine a root cause of application performance degradation, in an embodiment, information related to computing resources **502** and computing performance or resource data **504**, **506**, **508** determined by one or more third degree analysis **516** operations and/or functions is provided, by an analysis service **510**, to a dashboard **522**. In another embodiment, information related to computing resources **502** and computing performance or resource data **504**, **506**, **508** is provided, by an analysis service **510**, to a dashboard **522** regardless of whether any of the first degree analysis **512** operations and/or functions, second degree analysis **514** operations and/or functions, or third degree analysis **516** operations and/or functions are able to individually identify a root cause of application performance degradation.

If user-supplied diagnostics **518** indicate one or more additional levels or degrees of analysis operations and/or functions to be performed, as described above in conjunction with FIG. **3**, to facilitate root cause analysis, an analysis service **510** performs said additional levels or degrees of analysis. If one or more additional levels or degrees of analysis indicate information relevant to root cause analysis of application performance degradation, said information is provided, by an analysis service **510**, to a dashboard **522**.

FIG. **6**A illustrates an example dashboard agent **602** architecture to facilitate presentation of information **604**, **606**, **608**, **610** about one or more root cause issues to a user **614**. FIG. **6**B illustrates an example web interface to display information **604**, **606**, **608**, **610** in conjunction with a dashboard agent **602**. A dashboard agent **602**, as described above in conjunction with FIG. **2**, is data values and/or software instructions that, when executed, present or otherwise provide information about one or more root causes of application performance degradation related to computing resources of a computing resource services provider to a user **614**. In an embodiment, a dashboard agent **602** provides information through a web interface, such as that illustrated in FIG. **6**B, accessible by one or more users **614**. A web interface has controlled access for a specific user **614** or is generally usable by one or more users **614**. In another embodiment, a dashboard agent **602** generates one or more reports comprising information **604**, **606**, **608**, **610** about one or more root causes of application performance degradation. A dashboard agent **602** communicates or otherwise provides generated reports to one or more users **614**. A dashboard agent **602**, in another embodiment, uses any facility provided by a computing resource services provider to indicate information related to one or more root causes of application performance degradation identified by root cause analysis to one or more users **614**.

A dashboard agent **602** receives, from an analysis service **616**, information **604**, **606**, **608**, **610** related to one or more root causes of application performance degradation identified by root cause analysis operations and/or functions implemented or otherwise performed by a computing resource services provider. In an embodiment, a dashboard agent **602** receives, from an analysis service **616**, information comprising a selected timeframe **604** for presentation to one or more users **614** using presentation techniques described above and further described herein, such as in a web interface illustrated by FIG. **6**B. A selected timeframe **604** is one or more data values, specified or provided by a user in user-supplied diagnostics described herein, indicating a time window used to gather data analyzed during root cause analysis, as described above in conjunction with FIG. **5**.

In an embodiment, a dashboard agent **602** receives, from an analysis service **616**, information comprising resource metrics **606** for presentation to one or more users **614** using presentation techniques described above and further described herein. Resource metrics **606** are one or more data values indicating resource values determined by one or more

root cause analysis operations during root cause analysis, as described above in conjunction with FIG. **5**. For example, resource metrics **606** comprise data values indicating memory usage and network bandwidth associated with an application having degraded performance. Resource metrics **606** indicate one or more root causes of performance degradation determined by one or more first degree analysis operations, as described above in conjunction with FIGS. **2**, **3**, and **5**. Resource metrics **606**, in an embodiment, are displayed in a user interface such as a web interface illustrated by FIG. **6**B. A user interface, in an embodiment, is any graphical interface for displaying resource metrics **606**. Resource metrics **606**, in an embodiment, are filtered according to one or more performance indicators. Performance indicators are, in an embodiment, one or more data values usable to query, filter, reduce, or otherwise refine resource metrics **606** presented by a user interface. In an embodiment, performance indicators are provided by a user receiving or otherwise interacting with the user interface.

In an embodiment, a dashboard agent **602** receives, from an analysis service **616**, information comprising related triggers **608** for presentation to one or more users **614** using presentation techniques described above and further described herein. Related triggers **608** are one or more data values indicating second degree and/or third degree causes of application performance degradation identified by second degree or third degree analysis operations during root cause analysis, as described above in conjunction with FIGS. **2**, **3**, and **5**. For example, related triggers **608** comprise information indicating that a specific computing resource group provided by a computing resource services provider is experiencing degraded performance, such as "similar alarms triggered at this time" as illustrated in the example web interface of FIG. **6**B.

In an embodiment, a dashboard agent **602** receives, from an analysis service **616**, information usable for aggregation into a summary of causes for degraded application performance. Aggregated insights **610** is a set of collected resource metrics **606** summarized into data values that are understandable to one or more users **614**, as illustrated in the example web interface of FIG. **6**B. For example, aggregated insights **610** is a summary of computing resources used by an application having degraded performance, including indications of computing resources identified as one or more root causes of application performance degradation.

In an embodiment, a dashboard agent **602** comprises recommendations and/or remediation **612** operations to be performed in order to resolve application performance degradation. In another embodiment, a dashboard agent **602** does not present any recommendations and/or remediation **612** operations corresponding to one or more root causes of degraded application performance. If a dashboard agent **602** presents to a user, using presentation techniques described above, recommendations and/or remediation **612** operations to be performed in order to resolve application performance degradation, said dashboard agent may present an interface to automatically perform said recommendations and/or remediation **612** operations. For example, a dashboard agent **602**, in an embodiment, presents to one or more users **614** one or more user interface objects, such as buttons, usable to invoke automatic execution of one or more recommended operations or remediation operations.

Using information presented by a dashboard agent **602** using techniques described above, a user **614** receives information indicating one or more root causes of application performance degradation. One or more users, in an embodiment, perform one or more recommended operations or remediation operations indicated by a dashboard agent **602** or otherwise known to resolve application performance degradation due to one or more root causes presented by said dashboard agent **602**.

FIG. **6**B illustrates a web interface for presenting a monitoring dashboard comprising information from a dashboard agent **602**, as illustrated in FIG. **6**A. A web interface, in an embodiment, comprises a selected timeframe **604** indicating a data window for which one or more analysis operations were performed by a computing resource services provider, as described above in conjunction with FIG. **2**. In an embodiment, a web interface comprises a menu allowing one or more users of the web interface to select data and/or information items described above in conjunction with FIG. **6**A. For example, a menu allows a user, in an embodiment, to select resource groups related to one or more root causes displayed by a dashboard agent using a web interface.

In an embodiment, a web interface, such as that illustrated in **6**B, indicates additional resource information related to computing resources monitored as described above in conjunction with FIG. **2**. For example, database usage information, such as graphs and statistics, is usable by a web interface to communicate resource metrics **606** from a dashboard agent **602**. Aggregated insights **610** are also, in an embodiment, displayed by a web interface such as the web interface illustrated in FIG. **6**B. In an embodiment, aggregated insights **610** display performance graphics indicating computing resource performance during a specific time slice or time window. Additional log data and graphs comparing various resources related to a user application are displayed, in an embodiment, in conjunction with dashboard agent **602** information in a web interface such as that illustrated in FIG. **6**B.

FIG. **7** illustrates a process **700** for performing root cause analysis by a computing resource services provider using user-defined diagnostics. A computing resource services provider implementing or otherwise performing root cause analysis begins by receiving user-supplied diagnostics **702** from one or more users, as described above in conjunction with FIGS. **2** and **3**. A computing resource services provider monitors resources **704** indicated by received diagnostics **702** and/or predetermined computing resources for root cause analysis. If no trigger **706** is monitored or encountered indicating application performance degradation, a computing resource services provider implementing or otherwise performing root cause analysis continues monitoring resources **704**.

If a trigger **706** indicating one or more computing resources have exceed a threshold value or are otherwise causing application performance degradation, as described above in conjunction with FIG. **4**, then a computing resource services provider implementing or otherwise performing root cause analysis determines a data window **708** according to parameters specified by user-supplied diagnostics, as described above in conjunction with FIGS. **3** and **5**. A computing resource services provider implementing or otherwise performing root cause analysis gathers data **710** in a specific time slice or time window **708** indicated by user-supplied diagnostics or according to a default time slice or time window.

Once a computing resource services provider implementing or otherwise performing root cause analysis gathers relevant data **710**, said computing resource services provider implementing or otherwise performing root cause analysis performs first degree analysis **712** on said relevant data, as described above in conjunction with FIGS. **2**, **3**, and **5**. If additional layers or degrees of analysis are available **714**,

and/or if first degree analysis **712** failed to determine one or more root causes of application performance degradation, a computing resource services provider implementing or otherwise performing root cause analysis performs additional levels or degrees of analysis **712** by, if necessary, determining a new data window **708** and gathering data **710** relevant to additional levels or degrees of analysis to be performed **712**, as described above in conjunction with FIGS. **3** and **5**.

After a computing resource services provider implementing or otherwise performing root cause analysis completes all available analysis operations or one or more root causes of application performance degradation are identified by one or more analysis operations, said computing resource services provider implementing or otherwise performing root cause analysis presents root cause analysis results to a dashboard **716**, as described above in conjunction with FIGS. **2** and **6**. If user-supplied diagnostics include optional remediation steps to be performed, or if a computing resource services provider implementing or otherwise performing root cause analysis is able to perform automated remediation of one or more root cause issues affecting application performance, said computing resource services provider implementing or otherwise performing root cause analysis performs optional remediation **718**. If a user indicates that one or more optional remediation steps are to be performed **718**, in an embodiment, then a computing resource services provider implementing or otherwise performing root cause analysis performs said optional remediation steps to improve degraded application performance.

As one skilled in the art will appreciate in light of this disclosure, certain embodiments may be capable of achieving certain advantages, including some or all of the following: (1) customizable application resource monitoring adaptable to changing software application infrastructure and implementation leading to variable computing resource usage, (2) a single resource monitoring solution capable of user customization to facilitate identification of performance issues caused by computing resources across a diverse application infrastructure, (3) reduction of data presented for analysis in determining root causes of application performance degradation, and (4) leverage of diverse computing ecosystem to reduce gaps in data available to identify causes of application performance degradation. Certain embodiments may be capable of achieving certain additional advantages not listed herein. As described above, various mechanisms provide for monitoring of computing resources related to or responsible for degradation of application performance, and are readily extensible to monitoring of other aspects of software applications related to security and identity management.

FIG. **8** illustrates aspects of an example system **800** for implementing aspects in accordance with an embodiment. As will be appreciated, although a web-based system is used for purposes of explanation, different systems may be used, as appropriate, to implement various embodiments. In an embodiment, the system includes an electronic client device **802**, which includes any appropriate device operable to send and/or receive requests, messages, or information over an appropriate network **804** and convey information back to a user of the device. Examples of such client devices include personal computers, cellular or other mobile phones, handheld messaging devices, laptop computers, tablet computers, set-top boxes, personal data assistants, embedded computer systems, electronic book readers, and the like. In an embodiment, the network includes any appropriate network, including an intranet, the Internet, a cellular network, a local area network, a satellite network or any other such network and/or combination thereof, and components used for such a system depend at least in part upon the type of network and/or system selected. Many protocols and components for communicating via such a network are well known and will not be discussed herein in detail. In an embodiment, communication over the network is enabled by wired and/or wireless connections and combinations thereof. In an embodiment, the network includes the Internet and/or other publicly addressable communications network, as the system includes a web server **806** for receiving requests and serving content in response thereto, although for other networks an alternative device serving a similar purpose could be used as would be apparent to one of ordinary skill in the art. In an embodiment, a web server **806** receives diagnostics **818** as further described above in conjunction with FIGS. **2** and **3** to perform systems, methods, and techniques described herein.

In an embodiment, the illustrative system includes at least one application server **808** and a data store **810**, and it should be understood that there can be several application servers, layers or other elements, processes or components, which may be chained or otherwise configured, which can interact to perform tasks such as obtaining data from an appropriate data store. Application layers related to one or more application servers **808** comprise, in an embodiment, layers to perform root cause analysis **824** as described above in conjunction with FIGS. **1-7**, further comprising a dashboard **822** to be presented in conjunction with one or more web servers **806** and one or more application programming interfaces (APIs) **820** to facilitate diagnostics **818** usable for root cause analysis **824** as further described herein. Servers, in an embodiment, are implemented as hardware devices, virtual computer systems, programming modules being executed on a computer system, and/or other devices configured with hardware and/or software to receive and respond to communications (e.g., web service application programming interface (API) requests) over a network. As used herein, unless otherwise stated or clear from context, the term "data store" refers to any device or combination of devices capable of storing, accessing and retrieving data, which may include any combination and number of data servers, databases, data storage devices and data storage media, in any standard, distributed, virtual or clustered system. Data stores, in an embodiment, communicate with block-level and/or object-level interfaces. The application server can include any appropriate hardware, software and firmware for integrating with the data store as needed to execute aspects of one or more applications for the client device, handling some or all of the data access and business logic for an application.

In an embodiment, the application server provides access control services in cooperation with the data store and generates content including but not limited to text, graphics, audio, video and/or other content that is provided to a user associated with the client device by the web server in the form of HyperText Markup Language ("HTML"), Extensible Markup Language ("XML"), JavaScript, Cascading Style Sheets ("CSS"), JavaScript Object Notation (JSON), and/or another appropriate client-side or other structured language. Content transferred to a client device, in an embodiment, is processed by the client device to provide the content in one or more forms including but not limited to forms that are perceptible to the user audibly, visually and/or through other senses. The handling of all requests and responses, as well as the delivery of content between the client device **802** and the application server **808**, in an embodiment, is handled by the web server using PHP:

Hypertext Preprocessor ("PHP"), Python, Ruby, Perl, Java, HTML, XML, JSON, and/or another appropriate server-side structured language in this example. In an embodiment, operations described herein as being performed by a single device are performed collectively by multiple devices that form a distributed and/or virtual system.

The data store **810**, in an embodiment, includes several separate data tables, databases, data documents, dynamic data storage schemes and/or other data storage mechanisms and media for storing data relating to a particular aspect of the present disclosure. In an embodiment, the data store illustrated includes mechanisms for storing production data **812** and user information **816**, which are used to serve content for the production side. The data store also is shown to include a mechanism for storing log data **814**, which is used, in an embodiment, for reporting, computing resource management, analysis or other such purposes. In an embodiment, other aspects such as page image information and access rights information (e.g., access control policies or other encodings of permissions) are stored in the data store in any of the above listed mechanisms as appropriate or in additional mechanisms in the data store **810**.

The data store **810**, in an embodiment, is operable, through logic associated therewith, to receive instructions from the application server **808** and obtain, update or otherwise process data in response thereto, and the application server **808** provides static, dynamic, or a combination of static and dynamic data in response to the received instructions. In an embodiment, dynamic data, such as data used in various applications and services, are generated by server-side structured languages as described herein or are provided by a content management system ("CMS") operating on or under the control of the application server. In an embodiment, a user, through a device operated by the user, submits a search request for a certain type of item. In this example, the data store accesses the user information to verify the identity of the user, accesses the detail information to obtain information about items of that type, and returns the information to the user, such as in a results listing on a web page that the user views via a browser on the user device **802**. Continuing with this example, information for a particular item of interest is viewed in a dedicated page or window of the browser. It should be noted, however, that embodiments of the present disclosure are not necessarily limited to the context of web pages, but are more generally applicable to processing requests in general, where the requests are not necessarily requests for content. Example requests include requests to manage and/or interact with computing resources hosted by the system **800** and/or another system, such as for launching, terminating, deleting, modifying, reading, and/or otherwise accessing such computing resources.

In an embodiment, each server typically includes an operating system that provides executable program instructions for the general administration and operation of that server and includes a computer-readable storage medium (e.g., a hard disk, random access memory, read only memory, etc.) storing instructions that, if executed by a processor of the server, cause or otherwise allow the server to perform its intended functions (e.g., the functions are performed as a result of one or more processors of the server executing instructions stored on a computer-readable storage medium).

The system **800**, in an embodiment, is a distributed and/or virtual computing system utilizing several computer systems and components that are interconnected via communication links (e.g., transmission control protocol (TCP) connections and/or transport layer security (TLS) or other cryptographically protected communication sessions), using one or more computer networks or direct connections. However, it will be appreciated by those of ordinary skill in the art that such a system could operate in a system having fewer or a greater number of components than are illustrated in FIG. **8**. Thus, the depiction of the system **800** in FIG. **8** should be taken as being illustrative in nature and not limiting to the scope of the disclosure.

The various embodiments further can be implemented in a wide variety of operating environments, which in some cases can include one or more user computers, computing devices or processing devices that can be used to operate any of a number of applications. In an embodiment, user or client devices include any of a number of computers, such as desktop, laptop or tablet computers running a standard operating system, as well as cellular (mobile), wireless and handheld devices running mobile software and capable of supporting a number of networking and messaging protocols, and such a system also includes a number of workstations running any of a variety of available operating systems and other known applications for purposes such as development and database management. In an embodiment, these devices also include other electronic devices, such as dummy terminals, thin-clients, gaming systems and other devices capable of communicating via a network, and virtual devices such as virtual machines, hypervisors, software containers utilizing operating-system level virtualization and other virtual devices or non-virtual devices supporting virtualization capable of communicating via a network.

In an embodiment, a system utilizes at least one network that would be familiar to those skilled in the art for supporting communications using any of a variety of available protocols, such as Transmission Control Protocol/Internet Protocol ("TCP/IP"), User Datagram Protocol ("UDP"), protocols operating in various layers of the Open System Interconnection ("OSI") model, File Transfer Protocol ("FTP"), Universal Plug and Play ("UpnP"), Network File System ("NFS"), Common Internet File System ("CIFS") and other protocols. The network, in an embodiment, is a local area network, a wide-area network, a virtual private network, the Internet, an intranet, an extranet, a public switched telephone network, an infrared network, a wireless network, a satellite network, and any combination thereof. In an embodiment, a connection-oriented protocol is used to communicate between network endpoints such that the connection-oriented protocol (sometimes called a connection-based protocol) is capable of transmitting data in an ordered stream. In an embodiment, a connection-oriented protocol can be reliable or unreliable. For example, the TCP protocol is a reliable connection-oriented protocol. Asynchronous Transfer Mode ("ATM") and Frame Relay are unreliable connection-oriented protocols. Connection-oriented protocols are in contrast to packet-oriented protocols such as UDP that transmit packets without a guaranteed ordering.

In an embodiment, the system utilizes a web server that runs one or more of a variety of server or mid-tier applications, including Hypertext Transfer Protocol ("HTTP") servers, FTP servers, Common Gateway Interface ("CGI") servers, data servers, Java servers, Apache servers, and application servers that support operations. In an embodiment, the one or more servers are also capable of executing programs or scripts in response to requests from user devices, such as by executing one or more web applications that are implemented as one or more scripts or programs written in any programming language, such as Java®, C, C# or C++, or any scripting language, such as Ruby, PHP, Perl,

Python or TCL, as well as combinations thereof. In an embodiment, the one or more servers also include database servers, including without limitation those commercially available from Oracle®, Microsoft Sybase®, and IBM® as well as open-source servers such as MySQL, Postgres, SQLite, MongoDB, and any other server capable of storing, retrieving, and accessing structured or unstructured data. In an embodiment, a database server includes table-based servers, document-based servers, unstructured servers, relational servers, non-relational servers, or combinations of these and/or other database servers.

In an embodiment, the system includes a variety of data stores and other memory and storage media as discussed above that can reside in a variety of locations, such as on a storage medium local to (and/or resident in) one or more of the computers or remote from any or all of the computers across the network. In an embodiment, the information resides in a storage-area network ("SAN") familiar to those skilled in the art and, similarly, any necessary files for performing the functions attributed to the computers, servers or other network devices are stored locally and/or remotely, as appropriate. In an embodiment where a system includes computerized devices, each such device can include hardware elements that are electrically coupled via a bus, the elements including, for example, at least one central processing unit ("CPU" or "processor"), at least one input device (e.g., a mouse, keyboard, controller, touch screen, or keypad), at least one output device (e.g., a display device, printer, or speaker), at least one storage device such as disk drives, optical storage devices, and solid-state storage devices such as random access memory ("RAM") or read-only memory ("ROM"), as well as removable media devices, memory cards, flash cards, etc., and various combinations thereof.

In an embodiment, such a device also includes a computer-readable storage media reader, a communications device (e.g., a modem, a network card (wireless or wired), an infrared communication device, etc.), and working memory as described above where the computer-readable storage media reader is connected with, or configured to receive, a computer-readable storage medium, representing remote, local, fixed, and/or removable storage devices as well as storage media for temporarily and/or more permanently containing, storing, transmitting, and retrieving computer-readable information. In an embodiment, the system and various devices also typically include a number of software applications, modules, services, or other elements located within at least one working memory device, including an operating system and application programs, such as a client application or web browser. In an embodiment, customized hardware is used and/or particular elements are implemented in hardware, software (including portable software, such as applets), or both. In an embodiment, connections to other computing devices such as network input/output devices are employed.

In an embodiment, storage media and computer readable media for containing code, or portions of code, include any appropriate media known or used in the art, including storage media and communication media, such as but not limited to volatile and non-volatile, removable and non-removable media implemented in any method or technology for storage and/or transmission of information such as computer readable instructions, data structures, program modules or other data, including RAM, ROM, Electrically Erasable Programmable Read-Only Memory ("EEPROM"), flash memory or other memory technology, Compact Disc Read-Only Memory ("CD-ROM"), digital versatile disk (DVD) or other optical storage, magnetic cassettes, magnetic tape, magnetic disk storage or other magnetic storage devices or any other medium which can be used to store the desired information and which can be accessed by the system device. Based on the disclosure and teachings provided herein, a person of ordinary skill in the art will appreciate other ways and/or methods to implement the various embodiments.

The specification and drawings are, accordingly, to be regarded in an illustrative rather than a restrictive sense. It will, however, be evident that various modifications and changes may be made thereunto without departing from the broader spirit and scope of the invention as set forth in the claims.

Other variations are within the spirit of the present disclosure. Thus, while the disclosed techniques are susceptible to various modifications and alternative constructions, certain illustrated embodiments thereof are shown in the drawings and have been described above in detail. It should be understood, however, that there is no intention to limit the invention to the specific form or forms disclosed but, on the contrary, the intention is to cover all modifications, alternative constructions, and equivalents falling within the spirit and scope of the invention, as defined in the appended claims.

The use of the terms "a" and "an" and "the" and similar referents in the context of describing the disclosed embodiments (especially in the context of the following claims) are to be construed to cover both the singular and the plural, unless otherwise indicated herein or clearly contradicted by context. Similarly, use of the term "or" is to be construed to mean "and/or" unless contradicted explicitly or by context. The terms "comprising," "having," "including," and "containing" are to be construed as open-ended terms (i.e., meaning "including, but not limited to,") unless otherwise noted. The term "connected," when unmodified and referring to physical connections, is to be construed as partly or wholly contained within, attached to, or joined together, even if there is something intervening. Recitation of ranges of values herein are merely intended to serve as a shorthand method of referring individually to each separate value falling within the range, unless otherwise indicated herein, and each separate value is incorporated into the specification as if it were individually recited herein. The use of the term "set" (e.g., "a set of items") or "subset" unless otherwise noted or contradicted by context, is to be construed as a nonempty collection comprising one or more members. Further, unless otherwise noted or contradicted by context, the term "subset" of a corresponding set does not necessarily denote a proper subset of the corresponding set, but the subset and the corresponding set may be equal. The use of the phrase "based on," unless otherwise explicitly stated or clear from context, means "based at least in part on" and is not limited to "based solely on."

Conjunctive language, such as phrases of the form "at least one of A, B, and C," or "at least one of A, B and C," (i.e., the same phrase with or without the Oxford comma) unless specifically stated otherwise or otherwise clearly contradicted by context, is otherwise understood within the context as used in general to present that an item, term, etc., may be either A or B or C, any nonempty subset of the set of A and B and C, or any set not contradicted by context or otherwise excluded that contains at least one A, at least one B, or at least one C. For instance, in the illustrative example of a set having three members, the conjunctive phrases "at least one of A, B, and C" and "at least one of A, B and C" refer to any of the following sets: {A}, {B}, {C}, {A, B},

{A, C}, {B, C}, {A, B, C}, and, if not contradicted explicitly or by context, any set having {A}, {B}, and/or {C} as a subset (e.g., sets with multiple "A"). Thus, such conjunctive language is not generally intended to imply that certain embodiments require at least one of A, at least one of B and at least one of C each to be present. Similarly, phrases such as "at least one of A, B, or C" and "at least one of A, B or C" refer to the same as "at least one of A, B, and C" and "at least one of A, B and C" refer to any of the following sets: {A}, {B}, {C}, {A, B}, {A, C}, {B, C}, {A, B, C}, unless differing meaning is explicitly stated or clear from context. In addition, unless otherwise noted or contradicted by context, the term "plurality" indicates a state of being plural (e.g., "a plurality of items" indicates multiple items). The number of items in a plurality is at least two but can be more when so indicated either explicitly or by context.

Operations of processes described herein can be performed in any suitable order unless otherwise indicated herein or otherwise clearly contradicted by context. In an embodiment, a process such as those processes described herein (or variations and/or combinations thereof) is performed under the control of one or more computer systems configured with executable instructions and is implemented as code (e.g., executable instructions, one or more computer programs or one or more applications) executing collectively on one or more processors, by hardware or combinations thereof. In an embodiment, the code is stored on a computer-readable storage medium, for example, in the form of a computer program comprising a plurality of instructions executable by one or more processors. In an embodiment, a computer-readable storage medium is a non-transitory computer-readable storage medium that excludes transitory signals (e.g., a propagating transient electric or electromagnetic transmission) but includes non-transitory data storage circuitry (e.g., buffers, cache, and queues) within transceivers of transitory signals. In an embodiment, code (e.g., executable code or source code) is stored on a set of one or more non-transitory computer-readable storage media having stored thereon executable instructions that, when executed (i.e., as a result of being executed) by one or more processors of a computer system, cause the computer system to perform operations described herein. The set of non-transitory computer-readable storage media, in an embodiment, comprises multiple non-transitory computer-readable storage media, and one or more of individual non-transitory storage media of the multiple non-transitory computer-readable storage media lack all of the code while the multiple non-transitory computer-readable storage media collectively store all of the code. In an embodiment, the executable instructions are executed such that different instructions are executed by different processors—for example, in an embodiment, a non-transitory computer-readable storage medium stores instructions and a main CPU executes some of the instructions while a graphics processor unit executes other instructions. In another embodiment, different components of a computer system have separate processors and different processors execute different subsets of the instructions.

Accordingly, in an embodiment, computer systems are configured to implement one or more services that singly or collectively perform operations of processes described herein, and such computer systems are configured with applicable hardware and/or software that enable the performance of the operations. Further, a computer system, in an embodiment of the present disclosure, is a single device and, in another embodiment, is a distributed computer system comprising multiple devices that operate differently such that the distributed computer system performs the operations described herein and such that a single device does not perform all operations.

The use of any and all examples or exemplary language (e.g., "such as") provided herein is intended merely to better illuminate embodiments of the invention and does not pose a limitation on the scope of the invention unless otherwise claimed. No language in the specification should be construed as indicating any non-claimed element as essential to the practice of the invention.

Embodiments of this disclosure are described herein, including the best mode known to the inventors for carrying out the invention. Variations of those embodiments may become apparent to those of ordinary skill in the art upon reading the foregoing description. The inventors expect skilled artisans to employ such variations as appropriate, and the inventors intend for embodiments of the present disclosure to be practiced otherwise than as specifically described herein. Accordingly, the scope of the present disclosure includes all modifications and equivalents of the subject matter recited in the claims appended hereto as permitted by applicable law. Moreover, any combination of the above-described elements in all possible variations thereof is encompassed by the scope of the present disclosure unless otherwise indicated herein or otherwise clearly contradicted by context.

All references including publications, patent applications, and patents cited herein are hereby incorporated by reference to the same extent as if each reference were individually and specifically indicated to be incorporated by reference and were set forth in its entirety herein.

What is claimed is:

**1**. A computer-implemented method, comprising:

identifying usage of one or more computing resources by a software application performed by a computing resource services provider by at least:

receiving, through an application programming interface, one or more user-defined diagnostics from a user comprising:

a set of parameters indicating the one or more computing resources and one or more computing resource performance thresholds; and

information indicating a set of serverless compute functions to perform analysis operations corresponding to the one or more computing resources wherein the analysis operations are organized into a hierarchy comprising at least a first degree and a second degree, wherein the first degree of analysis operations is directed to a first computing resource, and the second degree of analysis operations is directed to a second computing resource dependent on the first computing resource;

monitoring performance data for the one or more computing resources indicated by the one or more user-defined diagnostics;

in response to the performance data indicating the one or more computing resources met the one or more computing resource performance thresholds, transmitting one or more application programming interface calls to a serverless compute service to cause the serverless compute service to launch the set of serverless compute functions to perform the analysis operations in hierarchical order to determine a cause of meeting the one or more computing resource performance thresholds, wherein analysis operations in the second degree are performed in response to analysis operations in the first

degree failing to determine the cause of meeting the one or more computing resource performance thresholds;

obtaining information indicating results of the analysis operations in the hierarchical order; and

providing the information indicating the results of the analysis operations to be presented in a user interface to the user.

**2**. The computer-implemented method of claim **1**, wherein the information indicating the set of serverless compute functions to perform the analysis operations further indicates a set of serverless compute functions to perform a set of remediation operations, the set of remediation operations performed in response to the results of the analysis operations.

**3**. The computer-implemented method of claim **1**, wherein the performance data is recorded by a computing resource monitoring service of the computing resource services provider and the computing resource monitoring service transmits one or more application programming interface calls to the serverless compute service in response to the performance data.

**4**. The computer-implemented method of claim **1**, wherein the user interface is a web interface comprising information about the performance data and the information indicating the results of the analysis operations, the web interface provided by the computing resource services provider.

**5**. A system, comprising:

one or more processors;

memory that stores computer-executable instructions that, if executed, cause the one or more processors to:

receive, by a computing resource services provider, via an interface, one or more user-defined diagnostics from a user comprising:

a set of parameters indicating one or more computing resources to be monitored; and

information indicating a set of serverless compute functions to perform a set of analysis functions grouped in hierarchy of one or more levels to be triggered in response to performance monitoring of the one or more computing resources indicating degraded performance;

in response to the performance monitoring indicating degraded performance of the one or more computing resources based on the one or more user-defined diagnostics, transmit one or more application programming interface calls to a serverless compute service to cause the set of analysis functions indicated by the one or more user-defined diagnostics to run in hierarchical order of the one or more levels until a level of the analysis functions in the hierarchical order determine a cause of the degraded performance, wherein a first computing resource associated with a first level of the analysis functions belongs to a second computing resource associated with a second level of the analysis functions; and

provide to the user results of performance of the set of analysis functions to enable performance of the one or more computing resources to be restored.

**6**. The system of claim **5**, wherein the computer-executable instructions further cause the one or more processors to monitor performance of the one or more computing resources using a computing resource monitoring service of the system and, in response to the performance monitoring indicating degraded performance, performing the set of analysis functions specific to the one or more computing resources monitored by the computing resource monitoring service.

**7**. The system of claim **5**, wherein the computer-executable instructions further cause the one or more processors to receive, via the interface, one or more usage values indicating degraded performance of the one or more computing resources.

**8**. The system of claim **5**, wherein the analysis functions comprise one or more first analysis operations and one or more second analysis operations, the one or more first analysis operations associated with the one or more computing resources and the one or more second analysis operations associated with one or more second computing resources associated with the one or more computing resources.

**9**. The system of claim **5**, wherein the performance monitoring of the one or more computing resources is performed using one or more performance data sets associated with the one or more computing resources for a time value received via the interface.

**10**. The system of claim **9**, wherein the results of performance of the set of analysis functions are provided to a web interface to the system indicating the results of performance of the set of analysis functions and the cause of the degraded performance.

**11**. The system of claim **5**, wherein the computer-executable instructions further cause the one or more processors to perform a remediation operation to restore performance of the one or more computing resources in response to the results of performance of the set of analysis functions.

**12**. A non-transitory computer-readable storage medium storing thereon executable instructions that, as a result of being executed by one or more processors of a computer system, cause the computer system to at least:

receive by a computing resource services provider one or more user-defined diagnostics from a user:

information indicating one or more computing resources to be monitored and a set of serverless compute functions to perform a set of analysis functions to diagnose a set of performance issues of the one or more computing resources, wherein the set of analysis operations are organized into one or more degrees in hierarchy, wherein a second degree of the analysis operations are specific to dependent computing resources to those computing resources indicated by a first degree of the analysis operations;

transmit one or more application programming interface calls to a serverless compute service to launch the set of analysis functions indicated by the one or more user-defined diagnostics;

run the set of analysis functions degree by degree in the hierarchy to determine at least one of cause of the set of performance issues, wherein analysis operations in subsequent degrees are not performed once the at least one cause of the set of performance issues is determined; and

update a dashboard interface of the user with a set of results of performance of the set of analysis functions.

**13**. The non-transitory computer-readable storage medium of claim **12**, wherein the executable instructions further comprise instructions that, as a result of being executed by the one or more processors, cause the computer system to receive, from an interface, the set of analysis functions to diagnose the set of performance issues of the one or more computing resources.

14. The non-transitory computer-readable storage medium of claim 12, wherein the executable instructions further comprise instructions that, as a result of being executed by the one or more processors, cause the computer system to perform a first subset of the analysis functions associated with the one or more computing resources and perform a second subset of the analysis functions associated with one or more second computing resources associated with the one or more computing resources.

15. The non-transitory computer-readable storage medium of claim 12, wherein the executable instructions that cause the computer system to update the dashboard interface with the set of results of performance of the set of analysis functions further include instructions that cause the computer system to perform a remediation operation to restore performance of the one or more computing resources.

16. The non-transitory computer-readable storage medium of claim 12, wherein the executable instructions further cause the computer system to receive the information indicating the set of performance issues of the one or more computing resources from a computing resource monitoring service, the information corresponding to one or more performance indicators received from an interface.

17. The non-transitory computer-readable storage medium of claim 12, wherein the executable instructions further cause the computer system to present the dashboard interface as a web interface comprising at least the set of results of performance of the set of analysis functions and the information indicating the set of performance issues of the one or more computing resources.

18. The non-transitory computer-readable storage medium of claim 12, wherein the set of analysis functions to determine at least one of a cause of the set of performance issues are performed, at least in part, by the serverless compute service.

19. The non-transitory computer-readable storage medium of claim 12, wherein the executable instructions further cause the computer system to receive information indicating the set of performance issues of the one or more computing resources from a computing resource monitoring service, the one or more computing resources specified using an interface to the computing resource monitoring service.

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